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A CRITICAL COMPARISON OF THE FACTORS INHIBITING THE DEVELOPMENT OF THREE SPECIES OF COTTON IN SOUTHERN NIGERIA.

BY

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I.—INTRODUCTION.

Since 1922 most of the biological experiments undertaken by the research officers of the Nigerian Agricultural Department have been planned to determine the best cotton for growing in the Southern Provinces and have included attempts " to ascertain those factors that may have militated against the introduction of American cotton . . . and to compare these factors with those limiting the production of indigenous cotton." (11; 1925.)

In the Annual Report for 1921 the Director stated " It has been decided that it is necessary to regard ourselves as starting *de novo* on the problem of finding a cotton for the Southern Provinces which will be suitable for export," and again in the Annual Report for 1922 he laid down three lines on which the problem was to be attacked; (*a*) time of planting experiments for Allen cotton, (*b*) testing of all possible improved strains of native and exotic cottons, and (*c*) investigations of all the diseases, pests, or physiological causes limiting the yield of good cotton.

The experimental work described in the present paper may perhaps be considered as the final contribution towards the investigations mentioned above (c). It is considered that a suitable indigenous cotton has been obtained by selective breeding by the Botanical Section of the Department, and the factors inhibiting the development of this species of cotton—though not of any improved strains—have now been analysed and compared with those affecting both the American Allen cotton and the indigenous cotton that is generally cultivated throughout the area under consideration.

A brief summary of previous surveys of inhibiting factors is given below since, in later parts of this paper, comparisons are made between certain of the results obtained during the present investigations and those obtained during previous cotton seasons. A more detailed summary of this nature has already been given in another publication (2; 1927).

Survey No. I. *Season 1923-24.*—At Moor Plantation, Ibadan; on (July-sown) Allen and Meko cottons. Mason and Jones (10; 1924).

Survey No. II. *Season 1924-25.*—Six plots in Ilugun district and six plots in the Oyo district; on (July-sown) Allen and Meko cottons. Mason and Wright (11; 1925).

Survey No. III. *Season 1924-25.*

(*a*) Two plots in the Ilugun district and two plots in the Oyo district; on (July-sown) Allen and Meko cottons. Pomeroy and Lean (13, 1925).

(*b*) At Moor Plantation, Ibadan; on (July-sown) Allen, Ishan and Meko cottons. Jones and Laycock, *see* Pomeroy and Lean (13; 1925).

(*c*) At Moor Plantation, Ibadan; on (June and September-sown) Allen and Meko cottons. Golding, *see* Pomeroy and Lean (13; 1925).

Survey No. IV. *Present experiment. Season 1925-26.*—At Moor Plantation, Ibadan, and Adio; on (July-sown) Allen, Ishan and Meko cottons.

Survey No. V. *Season 1926-27.*—At Ilorin; on (July-sown) Allen, Ishan, Kabba and Ilorin cottons. Lean (6; 1927).

Throughout the present paper the various surveys are referred to by the numbers given above.

II.—OBJECTS OF THE EXPERIMENT.

The main object of this experiment was to study the insect and fungoid factors affecting the following three species of cotton when grown in two different localities.

American Allen (*Gossypium hirsutum*, var. Allen's Long Staple).

Native Ishan (*G. vitifolium*).
Native Meko (*G. peruvianum*).

The three species were grown on two similar plots, one on the Moor Plantation, Ibadan, and the other in the forest country near Adio about four miles west of the Plantation. These plots will be referred to as the Plantation or M.P., and the Adio plots.

The second important aim of the experiment was a comparison of insect factors within and outside the close season area that had been created in 1923 over an experimental area of nine square miles round Moor Plantation (1, 1925, p. 69).

There were several other points arising out of the previous surveys that required elucidation. In the matter of shedding it was hoped to demonstrate definitely the amount of abscission due to direct insect attack and to the physiological environment alone. Further the experiment was designed to time the sequence of events

on the plants and to enucleate the precedence of the contributory factors that cause damage to the bolls: to show, for example, under what conditions such diseases as Anthracnose and *Pseudomonas malvacearum* follow on bollworm lesions and bug punctures.

For some time doubt has been expressed as to whether the spreading of insects from one variety of cotton to another in an adjacent plot has militated against the success of the cropping system adopted on the experimental farms of the Agricultural Department, and the present experiment was intended to give results bearing on this problem. (1, 1925, p. 74.)

III.—METHODS.

A.—Plot Selection.

1. (*a*) *Moor Plantation.*—The five acre plot used for the investigations was situated in the block A.6.S., which had been known to yield good cotton crops during past seasons. When comparing this plot with others on the Plantation the plot number A.6.S. will be employed. In 1924 this plot had been grown under yams from February to December and interplanted with cover crop (*Dolichos* sp.) in August. In 1925 this was followed by green manure (*Dolichos* sp.) until the planting of the cotton for the experiment.

(*b*) *Adio.*—This was also a five acre plot, but was freshly cleared from rather thick secondary bush a short time before the cotton was planted. Many of the larger trees were ring-barked and left standing, there were also a large number of stumps distributed throughout the plot as well as many oil palms, so that plants in various sub-plots were influenced by an excessive amount of shade for which allowance was made in the final calculation of yields. The plot was surrounded by a belt of high and thick bush, and there were a few native farms in the vicinity. Silk cotton trees were fairly abundant in the district.

2. *Arrangement of Sub-plots.*—The arrangement of sub-plots and areas for special examinations was identical on both plots, and is shown in the plan. The varieties were grown according to the usual plantation practice; in quarter acre plots (110 yards by 11) with the Allen alternating with Ishan and Meko. The following abbreviations have been adopted to denote Moor Plantation Allen, Ishan and Meko and Adio Allen, Ishan and Meko respectively. M.A., M.I., M.M.; A.A., A.I. and A.M.

B.—Methods of Planting.

The times of planting of the three varieties were the optimum dates determined by past experiments on the Plantation, *viz.*, the two native cottons were sown between July 1st and 10th, and the Allen between July 10th and 15th.

On the Plantation the plants were sown on both sides of ridges six feet apart, while at Adio they were sown on the top of ridges six feet apart. The ridges were at right angles to the length of the sub-plots, and there were fifty-five ridges in each plot. The Ishan and Meko stands were two feet apart and the Allen one foot apart. The number of seedlings per stand was reduced to two on August 1st. on the Plantation and on the 4th at Adio; singling was carried out on August 19th and 27th respectively. All cotton was uprooted during the last week in March.

C.—Individual Plant Examinations.

In general the methods employed during the present survey differed from those of previous surveys in that a few plants were examined in great detail and individually, while previously a large number of plants had been studied in the mass.

PLAN SHOWING ARRANGEMENT OF GAUGE PLOTS AND SPECIAL PLANTS.

The following description applies equally to both plots. As shown in the plan, two well separated blocks were selected for plant examination, each containing a quarter acre of each of the three varieties of cotton with the Allen placed between the Meko and Ishan.

Forty " examination stands " of each variety were marked as soon as the seedlings were a few inches above the ground. Twenty stands in each of the two sub-plots were chosen fortuitously by marking the middle stand in every other ridge except the first seven and last eight. At Adio this selection method had to be modified owing to the presence of trees since no special " examination stand " was selected in an area affected by shade. These special stands were reduced to two plants and later to single " examination plants " on the dates given above, and in this reduction no more care was taken to leave the best plant per stand than is usual in the ordinary plantation practice.

2. *Seedling Examinations.*—The forty " examination plants " of each variety were closely studied from the seedling stage onwards. In the early stages the amount of damage to the vegetative growth by leaf eating insects, aphids, etc., was noted once per week.

3. *Bud Shedding.*—Shed buds were collected and examined daily, and once a week the number shed was checked by counting the scars on the fruiting branches during the early weeks. It was realised that, without this scar counting, all bud sheds could not be accounted for, since many are shed when they are very minute and others shrivel up on the plant.

4. *(a) Flower Marking.*—A small aluminium label, weighing 0.012 gm., was tied on to the fruiting branch at the base of the pedicel on the day the flower opened, and all flowers were marked by a spot of Indian ink on one bract so that if the resultant bolls shed they could not be mistaken for those from adjacent non-examination plants.

(*b*) As will be shown later, the flowering during the season was exceptionally heavy and at about the time of the maximum flower production the original plans had to be modified, and instead of all forty plants being examined in full the number was reduced as follows:—

Moor Plantation.	Allen.	20	plants.	1,357	flowers	produced
	Ishan.	7	,,	767	,,	,,
	Meko.	6	,,	468	,,	,,
Adio.	Allen.	20	,,	1,497	,,	,,
	Ishan.	14	,,	815	,,	,,
	Meko.	13	,,	792	,,	,,

On all the remaining special plants flowers were marked and the sheds examined as described.

(*c*) The detailed labelling of flowers was concluded on the following dates :—

Moor Plantation.	Allen : Dec. 5th.	Adio.	Allen : Dec. 26th
	Ishan : Jan. 9th.		Ishan : Jan. 16th.
	Meko : Jan. 9th.		Meko : Jan. 16th.

(*d*) After the above dates, all flowers were counted and marked, but it was only determined whether they subsequently shed, mummied or matured. All marking of flowers was concluded on the following dates :—

Moor Plantation.	Allen : Dec. 19th.	Adio.	Allen : Jan. 16th.
	Ishan : Feb. 20th.		Ishan : Mar. 13th.
	Meko : Feb. 20th.		Meko : Mar. 13th.

In considering the total number of flowers produced, all flowers opening after the labelling of flowers was concluded were not taken into account since most of these had either not matured when the cotton was uprooted, or else produced very small bolls.

5. Boll Shedding.—Boll sheds were collected and examined daily, and having been collected in the field together with their respective labels their individual ages and past histories were known.

Detailed shed examination was continued until all numbered bolls had either shed, mummified or matured.

6. Collection of Mummied Bolls.—When a boll dried up on the plants before it had attained full size it was classified as a "mummied boll." All such mummies were removed from the plants as soon as they were fully dried, and were classified according to the cause of any damage. In the case of special bolls lesions had been noted prior to mummification.

7. Green Boll Examinations.—All bolls on the plants were examined *in situ* with the aid of a hand lens once a week; the number and distribution of bug punctures over the individual carpels, the presence of bollworm and fungoid lesions and of other anomalous features was noted.

8. Boll Harvesting.—Bolls were picked when ripe, the date of their opening having been recorded previously. In the laboratory the locks of the picked bolls were examined individually, the lint being classified into the following five grades.

(1) Good.

(2) Stained—either by *Nematospora gossypii*, *Pseudomonas* or by other causes.

(3) Fair.—This class included locks with lint damaged but not stained, being usually the result of simple stainer punctures not followed by internal boll diseases or else slight bollworm damage.

(4) Matted.—This class represented the more exaggerated form of damage as found in class 3.

(5) Useless.—Locks rendered useless by *Nematospora gossypii*, bollworms or other causes.

The causes of any of the above damage were recorded as well as the presence of internal proliferation.

In the analysis of damage evident on bud and boll sheds, mummied bolls and locks of harvested bolls, when two or more types of lesions were present on the same unit the damage was allotted equally to the causative factors concerned. It is admitted that such an arrangement is somewhat arbitrary, since it is impossible to determine how much of the damage was due to any single factor or whether the damage would have been much the same if one or two of the factors had been absent.

D.—Insect Gauges.

(1) The *Stainer Gauge* was carried out on areas selected from the two plots (*see* plan), and also on a plot of Meko grown alone on the Plantation.

(2) A *Bollworm Gauge* was carried out on other parts of the plots up to November the 14th.

(3) A *General Insect Gauge* was carried out over a quarter acre of each variety of cotton in the two localities.

E.—Growth Measurements.

In the sub-plots containing the forty examination plants another twenty plants of each variety were selected on which the weekly growth rate of the main axis, when pruned of all fruiting branches, was determined.

F.—Estimations of Loss of Photosynthetic Area.

Forty plants on the same sub-plots were utilised for leaf counts, the number of leaves whose midrib length exceeded ten cms. was determined weekly and the loss of photosynthetic area due to each parasite was assessed. *See* Mason and Jones (10, 1924).

G.—Leaf Roll and Leaf Curl Plant Estimates.

These counts were taken by Mr. C. J. Lewin on the experimental plots and his results are published in another paper in this bulletin (7, 1927).

H.—Meteorological Records.

Daily readings of rainfall and wet and dry bulb temperatures were taken on both plots at 9 a.m. Mr. C. J. Lewin has placed at the disposal of the writers readings taken from Livingston's standardised white spherical atmometers located on another plot on the Plantation.

I.—Division of Work.

The investigations were organised by the entomological section, the mycological author acting in an advisory capacity in doubtful cases of fungoid infection of sheds, developing bolls and locks, and in addition undertaking growth measurements, estimations of loss of photosynthetic area and periodic surveys for leaf roll and leaf curl.

IV.—INSECT INCIDENCE.

A.—Cotton Stainers.

Stainer index picking was carried out on all varieties of cotton in both localities, but some modifications of the original methods, described in a previous paper (1, 1925), were thought to be desirable; the sample plots were reduced in number and area from three to two and from one-eighth to one-sixteenth acre respectively. The average number of adults collected weekly on one-eighth of an acre still constituted the stainer index; but was calculated from the sum of the numbers on two one-sixteenth acre plots instead of from the average number of three one-eighth acre plots.

Index picking was commenced in the week ending September the 19th, 1925, and was terminated in the week ending January 30th, 1926; the numbers of adults collected weekly are depicted graphically in Chart No. 3, and the total numbers for the twenty weeks are shown in Table No. 1.

TABLE NO. I.

	Moor Plantation.			Adio.		
	Allen.	Ishan.	Meko.	Allen.	Ishan.	Meko.
Total No. adults collected.	8,855	3,692	4,932	1,211	540	359
%						
D. superstitiosus — Spotted form	58·7	63·0	67·3	4·1	16·3	7·5
superstitiosus — Banded form	4·65	4·6	3·0	1·7	11·9	6·7
melanoderes	36·6	32·1	29·4	93·4	71·1	84·4
ugandanus	0	0·1	0	0·7	0·7	1·4
fasciatus	0·05	0·2	0·3	0·1	0	0

It will be seen that stainers were far more numerous on Moor Plantation than at Adio in spite of the close season measures enforced in the former locality. As stated above, the Adio plot was surrounded by secondary bush which, in conjunction with its comparatively small area, may have partly accounted for the small stainer infestation, but neither of these facts explain the high proportion of *D. melanoderes* at Adio and the very small number of other species collected in the locality. Another remarkable feature was the absence of F.1. adult peaks in both localities in the case of *D. melanoderes*. From Chart No. 4, it will be seen that there were two peaks for this species on M.P. Allen (October 10th and November 7th), and one peak on Adio Allen (October 31st); no freshly-emerged F.1. adults were found before November the 26th, so all three peaks represent migrations. It seems probable that this species was unable to resist the aridity following the ' harmattan ' in December, and that either there was a very great mortality among F.1. nymphs (of which no evidence was obtained) or that a migration of F.1. adults took place shortly after the ultimate ecdysis. Fifth instar nymphs of this species are easily recognisable from those of *superstitiosus* and were found on the index plots at the end of December, although adults were rare in the succeeding month.

Stainers were more numerous on Allen than on either of the native varieties, and evidence is given later in this paper showing that the infestation on Ishan and Meko was increased by the proximity of Allen cotton. Although there were more stainers on Ishan than on Meko at Adio, the numbers on both varieties were small, and the excess has been shown to be exceptional as this is the only case in three years of index picking when the number on Ishan has exceeded that on Meko.

The stainer infestation on Moor Plantation was considerably greater in the season under review (1925-26) than in either 1924-25 or 1926-27. The number of nymphs was so great in the four weeks from November the 15th to December the 12th that counting was impracticable; the sample plots were denuded of nymphs once a week during that period. The weekly evaporation in cubic centimetres, determined by Livingston's standardised white spherical atmometers, was lower in 1925 than in 1924 for twelve out of sixteen weeks between August 30th and December the 19th; this may partly explain the greater infestation of stainers in 1925.

The ratio between flowers produced per acre in one week and the number of migrant adult stainers occurring on one acre in the succeeding week was determined weekly for all varieties of cotton up to December 5th. It should be remembered that the ratio—flowers produced to migrant adults—is too high in all cases as the figures for stainer incidence, obtained from the stainer index, represent the degree of repopulation on one-eighth of an acre and not actual population, but this does not affect the value of the figures for comparative purposes.

In Table No. 2 the ratios for all varieties of cotton in the two localities are shown, the first column referring to the flowering periods.

TABLE No. 2.

Week ending.	M.P. Allen.	Adio Allen.	M.P. Ishan.	Adio Ishan.	M.P. Meko.	Adio Meko.
September 19th	17	19	—	—	—	
„ 26th	28	24	12	—	9	—
October 3rd	10	16	8	-	17	—
„ 10th	22	21	72	—	42	16
„ 17th	79	52	157	9	100	119
„ 24th	13	21	46	11	37	19
„ 31st	3	36	30	17	8	51
November 7th	4	41	10	84	6	118
„ 14th	5	103	18	108	13	243
21st	17	240	55	384	63	321
„ 28th	77	734	84	932	38	537

It will be seen that there was concordance in the weekly fluctuations on the two Allen plots in nine cases out of ten; there were many more flowers per migrant at Adio than on Moor Plantation during the last five weeks of the period. In most cases, there were fewer flowers per migrant on Allen than on either of the native varieties in the two localities regarded separately. Although there

were, generally speaking, fewer flowers per migrant on Adio Ishan than on Adio Meko, only 9.0 *per cent.* of the Ishan seed cotton harvested was affected by internal boll disease as compared to 13.3 *per cent.* of the Meko.

B.—Bollworms.

A bollworm gauge was attempted in order to give comparative figures for bollworm incidence on the three varieties of cotton in the two localities after the manner of the stainer index.

For each variety two blocks of plants were chosen situated in two sub-plots in different parts of the plot. These two blocks, together, contained 960 plants which were numbered continuously. Each day, *i.e.*, six days per week, every 24th plant was examined. In this daily examination of forty plants every bud and boll on the plant was examined for signs of bollworm damage and they were picked if a bollworm appeared to be present. These buds and bolls were later examined in the laboratory and the bollworms classified. By this arrangement each plant was denuded of its bollworm population once per month; the figures obtained therefore give the monthly rate of repopulation by larvae, but this figure is also probably very close to the actual population figure.

Although satisfactory in other respects this gauge was found to entail a great deal of labour and it became necessary to discontinue it after the week ending November 14th.

TABLE No. 3.

Total Bollworm Gauge from August 23rd to November 14th and the Percentage nos. of the Species of the Principal Bollworms on the Three Cotton Varieties.

	Allen.		Ishan.		Meko.	
	M.P. %	Adio. %	M.P. %	Adio. %	M.P. %	Adio. %
Earias biplaga	15	32	5	38	8	36
Earias insulana	2	2	0	0	2	0
Diparopsis castanea ...	20	2	10	0	10	18
Heliothis obsoleta ...	23	2	5	12	2	0
Prodenia litura	2	6	14	12	12	5
Argyroploce leucotreta ...	35	41	67	38	58	27

NUMBER OF BOLLWORMS PER ACRE.

Total from Buds ...	14,322	12,474	424	636	1,590	1.802
Total from Bolls ...	16,786	9,240	1,802	212	4,770	530
Total from Buds and Bolls	31,108	21,714	2,226	848	6,360	2,332

TABLE NO. 4.

THE NUMBER OF GREEN BOLLS ON THE PLANTS PER ACRE ON NOVEMBER 21ST.

	Allen.	Ishan.	Meko.
Moor Plantation	130,438	218,678	180,200
Adio	137,368	129,638	171,084

TABLE No. 5.

COMPARISON OF THE PERCENTAGE NOS. OF THE PRINCIPAL BOLLWORMS ON BUDS AND BOLLS.

	Allen.		Ishan.		Meko.	
	Buds. %	Bolls. %	Buds %	Bolls. %	Buds. %	Bolls. %
Earias biplaga	25	19	30	5	34	4
Earias insulana	1	4	0	0	3	0
Diparopsis castanea	13	13	20	0	22	6
Heliothis obsoleta	21	7	10	5	3	0
Prodenia litura	5	2	20	16	9	10
Argyroploce leucotreta	26	48	20	79	3	80

As will be seen from Table No. 3, a far greater number of bollworms was found in the early part of the season on the Allen cotton than on either of the two native varieties, although at the end of the period under consideration there was actually a greater supply of bolls available for food on most of the native plots than on the Allen (Table No. 4).

Table No. 3 also shows that the bollworms were far more numerous on all cotton varieties on the Plantation than on the Adio plot. As was suggested in the similar case of the stainer this effect

may have been due to the small area of cotton at Adio and the presence of thick bush. Nevertheless, within a short distance of the plot there were several old native farms with cotton plants left over from the previous season and bearing occasional bolls.

The same Table No. 3 shows the proportion of the different species of bollworms. On the Plantation *Argyroploce leucotreta*, Meyr, was by far the most numerous bollworm, while on the Adio plot *Earias biplaga* was nearly as numerous as this bollworm.

Table No. 5 shows the relationship between bollworms found on buds and those found on bolls. Both *Earias biplaga*, Walk, and *Heliothis obsoleta*, F. seem to show a preference for buds while *A. leucotreta* was much more numerous on the bolls.

C.—General Insect Gauge.

A gauge was instituted to give comparative data as regards the miscellaneous insect population on the three varieties of cotton in the two localities throughout the flower production and bolling periods.

For this purpose three adjacent sub-plots of the three cotton varieties were taken and each divided into four quarter acre sections. Two alternative quarter acre sections were denuded of their entire active insect population once per week, the two sections being denuded on different days in order to diminish any error due to changes in the population caused by temporary climatic conditions. All active insects were collected by 'sweeping' the cotton plants and were examined in the laboratory.

The most interesting results arising out of this gauge were negative since very few insects of known economic importance were collected. *Helopeltis spp.* were not found in any appreciable number neither was the typical damage caused by these insects in evidence. Very few *Syagrus calcaratus*, F. adults were collected and very few plants appeared to suffer damage to the root system by the larvae of this beetle. Jassids were also uncommon.

During the latter part of September and the beginning of October the open flowers of all varieties were infested by great numbers of a small black Thrips, *Physothrips sjöstedti*, Tryb. The damage, if any, caused by this insect was not estimated.

V.—PLANT HISTORIES.

A.—General Growth of the Plants.

Table No. 6 indicates the dates of the principal phases on the three cotton varieties in the two localities.

TABLE No. 6.

Locality.	Cotton variety.	1st Bud, W.E.	Date of: 1st Flower.	Date of: Maximum flower production, W.E.	Maximum harvesting. Two weeks ending.
Moor Plantation	Allen ...	Aug. 22nd.	Sept. 9th.	Oct. 31st.	Dec. 12th.
	Ishan ...	„ „	„ 22nd.	Nov. 7th.	Jan. 9th.
	Meko ...	„ „	„ 21st.	Oct. 31st.	„ 2nd.
Adio	Allen ...	„ „	„ 16th.	Nov. 7th.	Dec. 19th.
	Ishan ...	Sept. 5th.	Oct. 11th.	„ 28th.	Jan. 9th.
	Meko ...	„ „	„ 8th.	„ 14th.	„ 16th.

Growth Measurement.

The curves obtained from plotting the weekly stem heights of the pruned plants have been compared with the theoretical curves calculated from Robertson's (14, 1923) formula for an autocatalyzed monomolecular reaction as modified by him to express the growth of many animals and plants.

This formula when integrated, yields the relation :—

$$\log.\frac{x}{a-x} = K(t-t_1)$$

where $K = K_1 a$ and t_1 is the time at which the reaction is half completed, that is when $x = \frac{1}{2}a$.

Except in the case of the Adio Allen, the observed and calculated values agree very closely indeed and in many cases the observed values were slightly above the calculated. For the Adio Allen, however, the curve from the observed values lies well below that from the calculated values, over the period from August 28th to November 27th. The total average height of these plants was also very low, 126 cms. as compared to 245 cms. for the M.P. Allen.

The average heights of the pruned native plants were as follows :—

Moor Plantation, Ishan, 335 cms. Meko, 380 cms.
Adio ,, , Ishan, 316 cms. Meko, 304 cms.

In all cases the Adio plants were smaller than those on the Plantation.

It is assumed that this inhibited growth of the Adio Allen was due to the loose nature of the soil. This imperfection would not have the same effect on the native plants owing to the great length of tap root in these species of cotton. At Adio, on all the three cottons, distinct symptoms of drought were observed, resulting presumably from the same cause. As will be shown later this was reflected in the amount of shedding.

B.—Seedling Examinations.

(1) General.—Insect damage to the vegetation of young plants was noted from germination in July to October the 27th, and in the Table No. 7 is shown the percentage of the forty plants of each variety attacked by various diseases in this period.

TABLE No. 7.

Locality and variety.	% attacked by Aphids.	% with Leaf Roll.	% with Leaf Curl.	% with *Alternaria* lesions.	% with Angular leaf spot.
M. P. Allen	100	20	2·5	35	2·5
Adio. „	95	35	2·5	25	0
M. P. Ishan	100	0	10	100	90
Adio. „	90	10	25	100	30
M. P. Meko	100	2·5	7·5	80	60
Adio. „	87·5	5	10	95	20

(2) Leaf Roll.—In the case of the physiological disease, leaf roll, nineteen unaffected plants of Adio Allen produced an average of seventy-nine flowers per plant and gave an average yield of 39.06 gms. of seed cotton while the corresponding figures for thirteen affected plants were fifty-three and 19.02 gms. respectively. This result is possibly a reflection of the effect of soil variability on the plants as the incidence of leaf roll has been shown to be intimately connected with soil humidity (3, 1926).

(3) Leaf Curl.—One plant of Allen at Adio was attacked by the virus disease, leaf curl, and produced only four flowers all of which were subsequently shed. The information obtained with regard to the effect of leaf curl upon the flowering and yield of affected native plants is contained in Table No. 8.

TABLE No. 8.

Locality and Variety.	Remarks.	Average No. flowers produced per plant.	Average yield of seed cotton per plant, in gms.
M.P. Ishan ...	*4 affected plants ...	96	78·22
	32 unaffected „ ...	101	80·20
Adio Ishan ...	*8 affected „ ...	48	35·03
	16 unaffected „ ...	60	56·10
M.P. Meko ...	*3 affected „ ...	43	22·75
	33 unaffected „ ...	78	79·44
Adio Meko ...	*2 affected „ ...	45	37·08
	28 unaffected „ ...	78	84·58

* Plants all affected by leaf curl on or before 27th October.

With the exception of M.P. Ishan average flower production and yield were markedly lower in plants affected by leaf curl than in those unaffected. The symptoms of leaf curl infection appeared earlier on the M.P. Meko plants than on M.P. Ishan, and the attack was more severe.

A number of plants of both varieties showed the first signs of infection in the last week of November and early December; no diminution in the flowering and yield of these plants was apparent, in fact, in several cases, they exceeded unaffected plants in these respects.

C.—Estimations of Loss of Photosynthetic Area.

(1) Photosynthetic Area Variations per Variety and Plot.

Estimates of photosynthetic area have been carried out by the methods used by Mason and Jones (10, 1924).

In order to compare the leaf areas on the different cottons the maximum number of leaves occurring at any one time has been taken (*see* Table No. 9).

TABLE No. 9.

Maximum Photosynthetic Area.

Variety.	No. of leaves in 1,000 per Acre.	
	Plantation.	Adio.
Allen	3,282	1,839
Ishan	6,612	3,423
Meko	6,001	3,299

(2). Loss of Photosynthetic Area.

(a) Loss due to Insects.—Table No. 10 gives the average percentage number of mature leaves lost through the ravages of leaf-eating insects over the entire season. The percentage lost increased steadily through the season so that the highest percentage loss came at a time when there were very few leaves remaining on the plants.

TABLE No. 10.

Variety.	Percentage loss.	
	Plantation.	Adio.
Allen	3·4	3·9
Ishan	2·9	2·7
Meko	3·6	3·1

It will be seen that the loss is inconsiderable but that the Ishan suffers the least in both localities. The pathogens were found to be the usual miscellaneous selection of coleoptera and lepidopterous larvae found feeding on cotton foliage as given in Appendix I, with no important differences between the varieties and plots.

(b) Loss due to Angular Leaf Spot and Alternaria.—Three assessments have now been made on Moor Plantation for the years 1923, 1924 and 1925. In the first season Mason and Jones worked on American and Meko varieties; in 1924 Jones and Laycock investigated fifty plants of American, Meko and Ishan varieties and in 1925 the estimation was repeated on forty plants of American, Meko and Ishan cottons both at Moor Plantation and Adio. As the records show considerable differences, the figures for the maximum amount of damage in any one week, together with those showing the average loss of leaf area, are arranged in Table No. 11.

These figures would appear to indicate that *Pseudomonas malvacearum* was more virulent in 1923 than in the two later seasons, but considering the period of three years they show that this organism is not so important a destructive factor on cotton plants in the Oyo Province as was at first thought. The complete immunity of the American plant to angular leaf spot disease in 1924 and 1925 is most striking and the small amount of damage to the native plants during these seasons is in great contrast to the large incidence in 1923. A comparison of the seasons 1923 and 1924 showed that the cultural conditions, *i.e.*, width of ridges, etc., the temperature, and the total rainfall were identical over the same period, but the bulk of the rain in the former season fell in October, one month after planting. Possibly this heavy rainfall may have been responsible for the large incidence of angular leaf spot in that year.

It is impossible to state, from the data available, how much the incidence of bacterial disease is affected by the time of planting but it seems significant that when the cotton was sown in July there was very considerably less loss from this source.

It is worth recording, too, that in 1923 there was no knowledge of the amount of damage due to *Helopeltis spp.* and, as the lesions caused by these so closely resemble those produced by *P. malvacearum*, it seems possible that a certain amount of damage, due to the former agents, may have been attributed to the latter. Indeed, in a footnote to Table X in the paper by Mason and Wright (11, 1925), the authors state: "It would appear that some of the damage hitherto attributed to black-arm may be the direct result of the feeding habits of *Helopeltis spp.*" The same diminution of damage, due to *P. malvacearum* will also be shown later when dealing with boll shedding.

A slight increase in the amount of damage due to *P. malvacearum* is recorded on Ishan, 1925. This is greater on Moor Plantation than on the Adio plot and might be attributed to the increased potentiality to infection on an area given over to cotton cultivation in successive seasons.

It might be mentioned, in passing, that the only fungus found on the leaves of American plants was *Kuchneola desmium*, Arth. which causes rust on old, moribund leaves.

The *Alternaria* fungus, which produces circular, zoned lesions, was a more important agent in producing loss of mature leaf area than was *P. malvacearum*. It should be mentioned that the loss from this source at Adio was probably greater than stated, for many leaves, which were regarded as defoliated physiologically, had their petioles ringed by elliptical *Alternaria* lesions. Even with the figures given it will be seen that *Alternaria* was more prevalent on native plants at Adio than on those of Moor Plantation during the same and the previous seasons. The reasons for the greater incidence will be discussed later in relation to *Alternaria* boll sheds.

TABLE No. 11.

Showing average percentage loss of leaf area per week due to Pseudomonas malvacearum and Alternaria sp. on all varieties of cotton on Moor Plantation and Adio Plots.

Variety of Cotton.	MOOR PLANTATION PLOTS.												ADIO PLOT.			
	Season 1923-24.				Season 1924-25.				Season 1925-26.				Season 1925-26.			
	P. malvacearum. Per cent. leaf damage.		*Alternaria sp.* Per cent. leaf damage.		*P. malvacearum.* Per cent. leaf damage.		*Alternaria sp.* Per cent. leaf damage.		*P. malvacearum.* Per cent. leaf damage.		*Alternaria sp.* Per cent. leaf damage.		*P. malvacearum.* Per cent. leaf damage.		*Alternaria sp.* Per cent. leaf damage.	
	Maximum.	Average	Maximum.	Average.	Maximum.	Average.	Maximum.	Average.	Maximum.	Average.	Maximum.	Average.	Maximum.	Average.	Maximum.	Average.
Allen	6	–	No record		0	0	0	0	0	0	0	0	0	0	0	0
Meko	16	–	No record		3·7	1·24	0·69	0·23	2·16	0·78	1·76	1·06	0·13	0·03	2·9	2·3
Ishan	Not grown				0·13	0·03	1·27	0·26	2·2	0·81	1·62	0·82	0·25	0·04	2.63	1·63

VI.—BUD SHEDDING.

It was thought probable that the collection of shed buds would not yield accurate figures as a number of buds wither on the plants before falling to the ground and, owing to their brittleness, rapidly disintegrate. For several weeks after the commencement of bud shedding bud scars on the fruiting branches were counted in order to determine the error when bud shedding is estimated from the number of shed buds collected from the ground beneath the plants daily.

Table No. 12 shows the percentage error for each variety in the two localities.

TABLE No. 12.

Locality and Variety.	No. of weeks of scar-counting.	Actual No. buds shed in period.	Percentage error.
M.P. Allen	4	306	27
Adio Allen	5	142	22·5
M.P. Ishan	3	414	38
Adio Ishan	5	292	28
M.P. Meko	4	509	38·5
Adio Meko	5	422	31

As scar counting is impracticable for more than five weeks after the commencement of bud shedding, and the error is so considerable when scar counting is not adopted, quantitative figures for the abscission of buds are of little value. Qualitative figures are also misleading as the majority of the buds not found by ordinary collection of buds from the ground are minute physiological sheds, therefore the percentage of shedding due to other factors is increased, although comparison of the degree of shedding caused by these other factors is not affected.

In Table No. 13 is shown the percentage of buds shed from various causes and the percentage of buds shed to buds produced, the bud production figures being arrived at by the addition of total buds shed and total flowers produced.

TABLE No. 13.

PERCENTAGE OF BUDS SHED.

Locality and Variety.	% Buds shed to buds produced.	Total No. of Buds shed.	% Boll-worm.	% Bug.	% Doubtful.	% Without lesions.	% Bacterial.	% *Alternaria.*
M.P. Allen	28	1,432	18·5	2·3	11 2	67·9	0·1	0
Adio „	23	993	19·5	0·2	10·4	69·3	0·6	0
M.P. Ishan	30	1,591	3·4	0·9	19·7	59·8	15·4	0·8
Adio „	26	916	4·15	0·4	21·5	67·35	4·5	2·1
M.P. Meko	38	1,788	3·3	0·6	21·4	56·5	17·3	0·9
Adio „	21	817	5·75	0·25	15·3	67·9	8·1	2·7

It will be seen that, while there was little difference in the percentage of buds shed to buds produced on the different varieties, there was considerable disparity in the percentage of abscission presumably due to insect and fungoid factors.

While the proportion of bollworm sheds was markedly greater on the two Allen plots than on the four native plots, the reverse was true of the proportion of *Alternaria* and bacterial sheds; also bacterial shedding was more common on the Plantation native varieties than on the same cottons at Adio, the reverse being true of *Alternaria* sheds.

As shown later similar phenomena were observed in the case of boll shedding.

A proportion of the shedding on native cotton on Moor Plantation was due to *Fusarium* following insect punctures. The buds appeared perfectly healthy except for small dark spots at the point of puncture. On opening such buds the whole of the androecium was found to be blackened and *Fusarium* was isolated. Needle inoculation experiments proved that *Fusarium* could produce this type of shedding.

VII.—FLOWER PRODUCTION.

The flower production of the three varieties of cotton in the two localities is shown in Chart I.

It will be seen that the curves representing the flower production obtained from the weekly figures of the forty examination plants is typical of an autocatalytic reaction up to the time of the maximum

flower production. Except in the case of the Moor Plantation Allen the curves are very smooth up to this date and it seems most unlikely that the flower production has been inhibited to any great extent by the loss of buds shed.

In the latter halves of the curves it is of interest to notice that whereas the two native cottons on the Plantation showed a distinct secondary flowering curve, on the Adio plot the flower production of both varieties fell nearly to zero with only a very slight subsequent rise. It is probable that this difference in the plots was due to drought, since later in the season the plants at Adio seemed to suffer from lack of moisture as shown by the wilting of the plants and by the increase of the percentage of undamaged bolls that were shed.

VIII.—BOLL SHEDDING.

As has been stated one of the principal objects of the experiment was an analysis of the causes of shedding.

Pomeroy and Golding (12, 1923) showed that "the feeding, and possibly other habits of the cotton stainer do result in more bolls and squares being shed on the cotton plant," at any rate under conditions of very heavy infestation.

In the following season Mason and Jones (10, 1924), found that there were no significant differences in the percentages of buds or bolls shed on plants that had been protected from stainers and on those that had been heavily attacked.

As a result of the surveys carried out during the 1924-25 season, Mason and Wright (11, 1925) concluded that, in the case of Allen cotton, no considerable loss of crop occurred as a result of shedding due to insect attack on *young* bolls. With regard to Meko, they expressed doubt as to whether the various pathogenic factors were responsible for excessive shedding by direct damage, but they considered that damage to the plant body was of importance.

In the same season Pomeroy and Lean (13, 1925) also found indications that, on Allen cotton, practically all the shedding was from physiological causes.

In the present investigations figures that have a more direct bearing on the shedding problem have been obtained, and in the following section the question has been approached from several different points of view.

A.—Allen Cotton.

(1). Direct Comparative Analysis of Shed and Persistent Bolls.

In the consideration of the shedding on this variety of cotton only the insect factors need be taken into account as, with the exception of internal boll disease, fungoid diseases were practically absent.

In the following section comparisons are made between the percentages of shed and persistent bolls bearing insect lesions; it should be remembered that in the case of stainer punctures such a comparison is complicated by the fact that *Dysdercus* is a vector of *Nematospora*. As the period of development of this disease is about four days, the shedding of only a very small number of bolls from 0-1 week old can have been due to internal boll disease.

TABLE NO. 14.

Moor Plantation Allen.

Comparison of Shed and Persistent Bolls.

Week ending.	Shed (S) or Persistent (P).	AGE OF BOLL. 0–1 Week. Per cent. damaged by				1–2 Weeks. Per cent. damaged by				2–3 Weeks. Per cent. damaged by				3–4 Weeks. Per cent. damaged by			
		Bollworm.	Bug.	Per cent. undamaged.	Total No. examined.	Bollworm.	Bug.	Per cent. undamaged.	Total No. examined.	Bollworm.	Bug.	Per cent. undamaged.	Total No. examined.	Bollworm.	Bug.	Per cent. undamaged.	Total No. examined.
Sept. 26	S	6	88	6	17	0	100	0	2								
	P	6	12	82	19	0	100	0	1								
Oct. 3	S	36	46	18	57	29	59	12	17								
	P	4	8	88	31	15	56	29	24								
10	S	46	39	15	61	31	56	13	47	50	50	0	1				
	P	3	30	67	60	23	65	12	41	26	70	4	24				
17	S	34	50	16	106	25	59	16	51	69	31	0	8	0	100	0	1
	P	7	33	58	113	20	71	9	66	40	57	3	41	50	44	6	17
24	S	32	47	21	114	17	65	18	60	33	67	0	3	30	70	0	5
	P	7	23	69	85	19	67	14	123	35	63	2	64	33	64	3	36
31	S	50	29	21	213	37	46	17	79	60	40	0	5				
	P	13	42	45	31	22	53	25	83	32	63	4	102	38	62	0	50
Nov. 7	S	44	30	26	315	22	55	23	109	29	64	7	14	25	75	0	2
	P	17	43	40	20	30	62	8	38	30	67	3	65	32	58	9	69
14	S	52	25	23	163	39	49	12	80	17	72	11	9	38	62	0	4
	P	17	33	50	12	56	44	0	24	43	55	2	45	40	56	4	72
21	S	51	19	30	54	34	57	9	22	25	75	0	4	50	50	0	2
	P	0	67	33	3	22	56	22	9	42	58	0	32	33	67	0	53
Total ...	Sheds ...	43	35	22	1,100	29	55	16	467	38	57	4	44	36	64	0	14
	Persistent Bolls* ...	12	37	52	474	29	59	12	409	36	61	2	373	35	59	5	297

* Totals for the persistent bolls obtained by taking the same number of persistent bolls as there were of sheds, week by week, and calculating the percentages from these corrected totals.

TABLE NO. 15.

Adio Allen.

Comparison of Shed and Persistent Bolls.

Week ending.		Shed (S) or Persistent (P).	AGE OF BOLL.															
			0–1 Week.				1–2 Weeks.				2–3 Weeks.				3–4 Weeks.			
			Per cent. damaged by		Per cent. undamaged.	Total No. examined.	Per cent. damaged by		Per cent. undamaged.	Total No. examined.	Per cent. damaged by		Per cent. undamaged.	Total No. examined.	Per cent. damaged by		Per cent. undamaged.	Total No. examined.
			Bollworm.	Bug.			Bollworm.	Bug.			Bollworm.	Bug.			Bollworm.	Bug.		
Oct.	3	S	47	41	12	17	75	25	0	4								
		P	0	20	80	5												
	10	S	12	41	46	41	21	74	5	21	0	100	0	2				
		P	6	19	75	24	25	8	67	6	0	100	0	1				
	17	S	28	35	37	57	28	72	0	23	25	75	0	2				
		P	8	11	81	43	12	64	24	25	50	50	0	6	0	100	0	1
	24	S	22	28	50	81	21	66	14	51	33	67	0	6	0	100	0	1
		P	4	21	75	67	12	44	44	41	25	67	8	24	43	57	0	7
	31	S	30	30	41	113	28	48	23	64	33	58	8	12	33	67	0	6
		P	9	15	76	62	19	57	24	70	28	52	20	40	40	60	0	24
Nov.	7	S	34	34	32	133	25	50	26	93	59	41	0	11	29	71	0	7
		P	11	31	58	61	24	63	13	61	35	62	3	58	43	57	0	28
	14	S	56	18	26	146	31	56	13	85	35	55	10	10	44	56	0	8
		P	18	32	50	52	27	58	15	67	32	66	2	60	40	60	0	60
	21	S	63	19	18	101	32	56	11	62	25	75	0	8	17	83	0	3
		P	20	31	49	37	26	58	16	57	31	64	5	54	38	60	2	43
	28	S	37	39	24	123	21	65	13	82	28	72	0	9	50	50	0	1
		P	13	42	45	20	17	62	21	33	32	64	4	45	36	64	0	43
Dec.	5	S	47	19	33	96	24	52	24	29	0	83	17	6	50	60	0	3
		P	10	29	61	31	26	59	15	27	33	57	10	38	34	64	2	57
	12	S	44	21	35	31	31	54	15	13	25	75	0	4	50	50	0	1
		P	17	12	71	21	18	68	14	30	38	54	8	24	40	57	3	37
	19	S	18	24	58	19	29	35	35	17	50	50	0	2				
		P	4	25	71	24	10	67	23	21	22	75	3	30	42	50	8	25
	26	S	25	37	38	8	20	50	30	10	0	0	100	1				
		P	20	20	60	5	6	46	48	25	14	71	15	21	22	74	3	29
Jan.	2	S	50	17	33	3	0	67	33	3								
		P	7	64	29	7	30	50	20	5	25	54	21	24	23	64	13	22
Total		Sheds ...	39	28	32	969	26	57	17	557	31	63	6	73	35	65	0	30
		Persistent Bolls. *...	12	27	61	459	21	56	22	468	30	63	6	425	39	60	1	376

* As in Table No. 14.

(a) Bolls 0-1 Week old.—From Tables Nos. 14 and 15, it will be seen that, throughout the season, the percentage of bolls bearing bollworm lesions was higher in the case of sheds from 0-1 week old than in that of bolls which did not shed at that age. In the case of bolls bearing stainer lesions the total percentage of sheds damaged was almost identical with the total percentage of persistent bolls damaged in both localities, although for the first five weeks on Moor Plantation and the first six weeks at Adio the shed percentage exceeded the persistent percentage.

It can therefore be concluded that bollworm lesions are a direct cause of abscission in the case of bolls shed when 0-1 week old, and that bolls of this age may be liable to shed as a result of stainer punctures in the first part of the season, but that stainer punctures are not potent causes of abscission. About sixty-five *per cent.* of the total shedding was of bolls of this age.

(b) Bolls 1-2 Weeks old.—With bolls of this age the case was different; the total percentage of bolls undamaged did not differ to any great extent for shed and persistent bolls, being sixteen and twelve respectively on Moor Plantation and seventeen and twenty-two at Adio, and even for bollworms the percentages were the same. It is concluded that almost the entire shedding of bolls of this age is due to physiological causes and not to direct insect attack. About thirty *per cent.* of the total shedding was of bolls of this age.

(c) Bolls 2-4 Weeks old.—The available figures are rather too limited to give any conclusive results, but there seems little difference between shed and persistent bolls 2-3 weeks old, and the difference is not very marked in the case of bolls 3-4 weeks old.

(2). Total Percentage of Sheds to Flowers Produced.

While it has been shown that insects, especially bollworms, do cause the shedding of bolls from 0-1 week old, it has yet to be shown whether these bolls, if they had escaped abscission in their first week, would still have been shed from physiological causes in their second week, or whether they would have remained on the plants to augment the final yield of seed cotton.

A series of figures is available from previous surveys giving the total percentage of bolls shed to flowers produced on Allen cotton grown during four seasons, in eleven different localities and with three different times of planting.

TABLE No. 16.

Season.	Survey No.	Locality.	Time of Planting.	Total per cent. Boll Sheds.
1923–24 ...	I	Moor Plantation	July	66
1924–25 ...	II	Ilugun Plot 1	„	87*
		Ilugun Plot 7	„	95*
		Oyo Plot 1	„	68
		Oyo Plot 3	„	67
		Oyo Plot 7	„	67
		Oyo Plot 9	„	67
	III *a*	Ilugun Plot 5	„	82*
		Oyo Plot 5	„	70
	III *a*	Moor Plantation	„	58
	III *c*	Moor Plantation	June	69
		Moor Plantation	September	65
1925–26 ..	IV	Moor Plantation	July	66
		Adio	„	69
1926–27 ...	V	Ilorin	„	64

It will be seen that except for the three observations marked with an asterisk the total shedding percentage is remarkably constant considering the variations in environment.

In the case of Ilugun plots 1 and 7, Mason and Wright (11, 1925) state that " there seems little doubt, however, that the percentages shown in the table are excessive, partly because the work was not begun until the second or third week of flowering, and partly because the luxuriant growth of the American plants at Ilugun rendered the counting of flowers a matter of great difficulty." The exceptionally high shedding figure on the third Ilugun plot was almost certainly due to the same causes.

It seems therefore that the shedding of about two-thirds of the flowers produced is normal for the Allen plant. It will be seen, however, that the total shedding is higher at Adio than on the Plantation and that the Adio figures of sixty-nine *per cent.* is above the average. Any excess of shedding was probably due to the inhibited growth of the plants.

(3). Average Age of Boll Sheds.

Tables Nos. 17 and 18 give the average age of sheds of all types for each week throughout the season, and the average age of each type of shed (derived from figures for the entire period).

TABLE No. 17.

AVERAGE AGE OF SHEDS OF ALL TYPES IN DAYS.

Week ending.	ALLEN.	
	M.P.	Adio.
September 26th ...	5·6	6·0
October 3rd ...	6·5	6·3
„ 10th ...	7·2	6·7
„ 17th ...	7·2	6·7
„ 24th ...	7·9	7·8
„ 31st ...	6·5	8·1
November 7th ...	6·7	8·1
„ 14th ...	7·5	8·1
„ 21st ...	7·4	8·2
„ 28th ...	8·6	7·7
December 5th ...	7·7	8·1
„ 12th ...	7·6	8·8
December 19th ...	17·0	9·3
„ 26th ...	24·2	8·6
January 2nd ...	42·0	7·6
„ 9th ...	33·5	18·8
„ 16th ...	42·0	37·0
*Average before December 13th ...	7·1	7·9

TABLE No. 18.

AVERAGE AGE OF SHEDS OF EACH TYPE IN DAYS.

Type of lesion on Boll.	ALLEN.	
	M.P.	Adio.
Undamaged ...	5·8	6·6
Bollworm ...	5·9	6·2
Bug	7·7	9·4

* Totals after December 12th are too small to attach much importance to the percentages.

It has been observed that the average age of shed bolls infected by internal boll disease is above the normal average age of sheds and this explains the average age of bug sheds being so definitely higher than that of other sheds. It has also been found that bolls infected with *Nematospora sp.* in the early stages are shed in the majority of cases and therefore internal boll disease has to be considered as an abscission-causing factor on Allen cotton.

As shown in Table No. 18, the average age of all types of sheds is greater at Adio than on the Plantation and the difference is most marked with the sheds damaged by bugs. In addition the difference in age is especially marked between weeks ending October 31st and November 21st, the period during which shedding was at its maximum.

It is therefore presumed that any excess of shedding that took place at Adio on Allen cotton was caused by the loss of bolls somewhat older than those under normal conditions and that these were damaged more by bugs than by bollworms.

(4). Direct Comparison of amount of Stainer damage on Shed and persistent Bolls.

In comparing the number of punctures on sheds and on bolls on the plants, it should be pointed out that the figure given for persistent bolls is too low as punctures under the calyx escaped enumeration.

As was to be expected, in the case of bolls 0-1 week old, it was found that the sheds were definitely more damaged than bolls that did not shed at this age; thus of the bolls damaged by stainers there was a far greater number of punctures per boll on sheds than on persistent bolls.

The average numbers of punctures per boll over the season for the persistent bolls are obtained as in the similar case in Tables Nos. 14 and 15.

TABLE NO. 19.

ALLEN COTTON: AVERAGE NUMBER OF PUNCTURES PER SHED AND PERSISTENT BOLL.

Age of Bolls.	M.P.		ADIO.	
	Shed.	Persistent.	Shed.	Persistent.
1–2 weeks	5·3	4·0	7·8	4·6
2–3 weeks	5·8	5·7	9·6	6·3

For bolls 1-2 and 2-3 weeks old it will be seen in Table No. 19 that on the Plantation there was no great difference between the number of punctures on the sheds and on the persistent bolls considering the error mentioned above. The differences at Adio are, however, much more marked and it is shown that of bolls of both these ages the sheds are more damaged than those bolls that did not shed.

(5). General Conclusions on Allen Boll Shedding.

Since about two-thirds of the bolls produced will shed under normal conditions it is concluded that if the young bolls, from 0-1 week old, had not shed, largely through the agency of direct insect damage (bollworm especially), about the same number would have been subsequently shed from physiological causes, their shedding does not therefore normally represent any diminution in the number of bolls that will produce the crop. In Tables Nos. 14 and 15 it is shown that the majority of undamaged sheds absciss during the first two weeks of their development and practically all within the first three weeks. It is presumed then, that if the bolls had not shed in their first week the majority would have shed during the

subsequent week and nearly all within the next week. However, it has been shown that the shedding of bolls from 0-1 week old is selective in that the damaged bolls are the most likely to shed, and the shedding of one to two week old bolls appears to be non-selective, therefore it is concluded that the greater the number of the youngest bolls to shed so long as the total shedding percentage of sixty-six is not exceeded the better will be the quality of the ultimate crop.

From the various considerations that have been discussed above it is not considered that the extra number of punctures on the Adio sheds was the primary cause of abscission, but that owing to the abnormal growth reaction of the plants an increase of shedding resulted over and above the normal sixty-six *per cent.*, and that this extra shedding was selective in so far as those bolls most damaged were the first to shed.

B.—Native Cotton.

(1). Direct Comparison of Bolls Shed and Bolls subsequently Harvested.

Shed and persistent bolls have been compared throughout the season for both native varieties in the same manner as with the Allen cotton. Since, however, there is no close agreement between the two classes of bolls, only the total percentages are given during the first four weeks of their development.

In all cases it will be seen that there is no agreement between the total percentage of shed and persistent bolls that were undamaged at the same age, from which it is concluded that the injuries found on the shed bolls were the main contributory cause of abscission. In the case of damage by bugs it is interesting to note, however, that there is no great difference between the percentage of sheds and of persistent bolls that exhibited bug punctures and that in a few cases of the older bolls a higher percentage of persistent bolls were damaged in this way, so that it seems probable that on the native cottons the stainers did not cause any excess of shedding by direct damage to the bolls.

It is also clearly demonstrated that although bollworms probably cause a certain amount of abscission of bolls of all ages they are a far more potent abscission-causing factor in the first week, as was also the case with the Allen cotton.

For similar reasons it appears that both bacterial disease and *Alternaria* are potent abscission-causing factors; in very few cases did bolls attacked by either of these two factors in the first four weeks of their development remain on the plants.

TABLE No. 20.

Ishan and Meko, Moor Plantation and Adio.

Comparison of Shed and Persistent Bolls.

Age of Boll.		Ishan.				Meko.			
		Moor Plantation.		Adio.		Moor Plantation.		Adio.	
		S.	*P.	S.	*P.	S.	*P.	S.	*P.
	%								
0–1 Week.	Damaged by Bollworm	18	2	10	5	20	3	9	2
	,, Bug	26	11	18	10	24	14	18	7
	,, Bacteria	21	0	2	0·2	19	0	3	0·2
	,, *Alternaria*	7	0	22	0·2	10	0	23	0
	,, Anthracnose ...	.08	0	0	0	0	0	0	0
	Undamaged	24	87	43	77	22	72	43	89
	Total No. examined	578	196	549	239	325	189	440	175
	%								
1–2 Weeks.	Damaged by Bollworm	10	8	6	9	9	8	4	4
	,, Bug	48	48	43	32	44	39	32	27
	,, Bacteria	14	0·1	0.3	0	14	3	1	0
	,, *Alternaria*	4	0·1	6	0·4	7	0·1	9	0·6
	,, Anthracnose ...	0	0	0	0	0	0	0	0
	Undamaged	19	37	38	58	20	49	47	68
	Total No. examined	655	269	494	346	316	507	436	455
	%								
2–3 Weeks.	Damaged by Bollworm	7	6	5	10	11	9	6	7
	,, Bug	73	73	66	49	60	70	55	57
	,, Bacteria	9	0·1	2	0·01	14	0·4	0·7	0
	,, *Alternaria*	4	0·2	4	0·1	3	0	3	0·7
	,, Anthracnose ...	0	0	0	0	0	0	0	0
	Undamaged	2	7	18	23	6	11	30	35
	Total No. examined	176	270	112	339	83	504	138	472
	%								
3–4 Weeks.	Damaged by Bollworm	11	17	3	19	11	10	7	12
	,, Bug	75	78	75	56	70	83	62	66
	,, Bacteria	6	1	0	0	10	0·7	1	0
	,, *Alternaria*	2	0·5	16	4	2	0	4	1
	,, Anthracnose ...	2	0	0	0	3	0	0	0
	Undamaged	1	3	0	19	2	3	26	21
	Total No. examined	71	269	16	326	59	460	35	454

* *Vide* footnote under Table No. 14.

(2). Total Percentage of Sheds to Flowers Produced.

A series of sixteen total shedding percentage figures is available for Meko comparable to those given for Allen with one addition, but there are only four Ishan figures.

The Meko figures are very variable and there is perhaps a slight relationship between the locality and the total percentage of bolls shed as shown in Table No. 21.

TABLE No. 21.

MEKO : TOTAL SHEDDING PERCENTAGE.

Locality.	% BOLLS SHED.			No. of plots.
	Maximum.	Minimum.	Average.	
Ilugun and Adio ...	66	38	49	4
Moor Plantation ...	42	31	35	6
Oyo and Ilorin	50	21	37	6
Total	66	21	39·5	16

It appears that there is a greater susceptibility to shed in the forest zone than in the more open country and in the present experiment the total shedding percentage was higher for both native cottons on the Adio plot than on the Plantation; this augmentation of shedding was possibly directly due to the inhibited growth of the plants at Adio.

The Ishan figures are not sufficient for any such comparison; the average total percentage from the four examples is forty-seven *per cent.* as compared to 39.5 *per cent.* for the Meko, and in the present experiment shedding was heavier at Adio than on the Plantation.

(3). Average Age of Boll Sheds.

Tables Nos. 22 and 23 give the average age of sheds of all types for each week throughout the season and the average age of each type of shed (derived from figures for the entire period).

TABLE No. 22.

Average Age of Sheds of all Types, in days.

Week ending.	Ishan.		Meko.	
	M.P.	Adio.	M.P.	Adio.
Oct. 3	8·0	...	5·75	...
10	5·75	...	6·7	...
17	5·8	·0	4·6	3·7
24	6·6	3·7	6·7	4·5
31	7·6	6·0	7·6	5·85
Nov. 7	8·6	5·5	9·0	7·2
14	9·1	7·4	10·4	7·1
21	10·0	6·6	9·7	6·9
28	10·3	9·0	11·8	9·1
Dec. 5	11·5	8·8	11·6	10·3
12	11·8	8·3	12·1	9·4
19	15·3	8·8	13·85	10·6
26	19·4	11·0	21·9	11·4
Jan. 2	23·7	10·5	24·1	14·85
9	18·9	16·6	21·5	16·45
16	15·5	45·7	20·3	24·2
Average before Dec. 13th... ...	9·3	7·9	9·5	8·5

TABLE No. 23.

Average Age of Shed of each Type, in days.

Type of lesion on Boll.	Ishan.		Meko.	
	M.P.	Adio.	M.P.	Adio.
Undamaged. ...	7·5	7·4	7·8	8·6
Bollworm	10·7	6·2	6·6	7·7
Bug...	13·2	11·6	14·8	10·3
Alternaria ...	7·7	5·0	6·9	6·0
Bacteria	8·1	5·2	7·9	6·6

As with the Allen cotton it was found that the average age of the bug sheds is definitely higher than the age of all other types of sheds and this may again be explained by the fact that a considerable amount of the sheds of this type are infected with *Nematospora* which causes shedding of bolls older than normal. The fact that

in the case of both native cottons the average age of bug sheds is higher on the Plantation than at Adio may be correlated with the fact that internal boll disease was much more prevalent in the former locality.

(4). Comparison of Boll Sheds due to Pseudomonas malvacearum *and* Alternaria sp. *on Moor Plantation and Adio Plots.*

It has already been indicated that bacterial disease and *Alternaria* are potent abscission factors, but the striking differences in the incidence of these factors in the two localities remain to be elucidated. It also is desirable to summarise the amount of damage caused by bacterial shedding during the last three seasons. Table No. 24 shows that there has been a steady diminution of shedding due to this factor on American and Meko plants on Moor Plantation.

TABLE No. 24.

SHOWING PERCENTAGE OF BACTERIAL SHEDS DURING THREE SEASONS.

Variety.	Moor Plantation.			Adio.
	1923.	1924.	1925.	1925.
Allen	12·0	0·7	Nil	Nil
Ishan	No record	5·6	6·1	0·5
Meko	18·7	6·8	4·0	0·7

As already stated, the damage to the plant body caused by *P. malvacearum* is greatly reduced since 1923, and it is interesting to note a parallelism to this with regards to boll shedding. It will be noted that there were no bacterial sheds on American cotton in both localities in 1925 and few on the native varieties of cotton at Adio, where forest conditions obtained. A corresponding reduction was noted by Mason and Wright in the forest zone at Ilugun (11, 1925). It has been suggested that the absence of bacterial disease in the extreme south of Nigeria may possibly be the result of the considerably higher mean temperature which obtains there, but this can hardly be regarded as applicable at Adio, which was only four miles away from Moor Plantation, and where the temperature did not differ materially. The greater potential infectivity on Moor Plantation, together with the fact that the Adio plot was previously in secondary bush, may account for the differences observed

on the two plots. Reviewing the incidence of *P. malvacearum* over the three seasons on Moor Plantation, it would appear that this factor is not so important as the 1923 figures indicate. True, in that year, the cotton was planted in September, and there was as much as 8.33 inches of rain in October. Whilst this would, naturally, result in a large incidence of bacterial disease, the amount recorded appears to be excessive, particularly when compared with the small incidence during the following season when the total rainfall was the same, although it was more evenly distributed over September and October. In this connexion it might be mentioned that Mason and Wright (11, 1925) point out " that there was unfortunately a tendency in the earlier stages of the work to confuse damage due to *Pseudomonas* with that due to the blackening that accompanies autolysis." Whatever was the reason for the high incidence in 1923, the figures obtained during the following two seasons indicate that *Pseudomonas* is not a very important boll-shedding factor in the Ibadan district. It will be noted that there is a slight increase in the percentage of bacterial sheds on Ishan during the season 1925.

With regard to shedding due to *Alternaria* there was as great a difference in the amount of damage due to this factor on both plots as there was in the case of bacterial disease; but *Alternaria* was the principal agent causing shedding on native plants at Adio. The figures for both fungoid agents for both plots are given in Table No. 25.

TABLE No. 25.

TOTAL BACTERIAL AND ALTERNARIA SHEDS AND PERCENTAGE OF SHEDS TO BOLLS PRODUCED ON MEKO AND ISHAN COTTON PLANTS ON MOOR PLANTATION AND ADIO PLOTS.

Variety and Locality.	No. of Bolls.	No. of *Alternaria* Sheds.	% *Alternaria* Sheds to Bolls produced.	No. of Bacterial Sheds.	% Bacterial Sheds to Bolls produced.
M.P. Ishan ...	4,641	79	1·7	274	5·9
Adio „ ...	2,690	172	6·4	14	0·52
M.P. Meko ...	3,840	76	1·9	156	4·06
Adio „ ...	3,098	164	5·2	22	0·71

The importance of *Alternaria* as a boll-shedding factor at Adio is interesting as the same result was obtained by Mason and Wright in 1924 on native cotton grown in the forest zone of Ilugun, where conditions obtained which approximated to those at Adio.

This difference in the incidence of *Alternaria* at Adio, as compared with that on Moor Plantation, appears to be correlated with the greater humidity which obtained at the former place and the correlation between the percentage *Alternaria* sheds and the relative humidity in the two localities is shown in Chart 2.

The great difference in shedding due to *Alternaria* is brought out in Table No. 26 which shows the damage due to this factor for the period October 31st to December 5th when the differences in relative humidity on both plots were most pronounced.

TABLE No. 26.

ALTERNARIA BOLL SHEDS ON NATIVE COTTON PLANTS AT M.P. AND ADIO DURING THE PERIOD OCTOBER 31ST TO DECEMBER 5TH WHEN THE AVERAGE RELATIVE HUMIDITY WAS GREATER AT ADIO THAN AT M.P.

	Moor Plantation.		Adio.	
	Ishan.	Meko.	Ishan.	Meko.
Total flowers produced (advanced one week)	2,827	1,953	1,778	1,999
Total Bolls Shed	1,217	644	792	657
Total *Alternaria* Sheds... ...	61	43	160	135
% *Alternaria* Sheds	2·1	2·2	9·0	6·7

The lesion due to *Alternaria* is usually situated in the glandular area at the base of the boll between the bracts, but in certain of the sheds the lesion was an elliptical zone on the pedicel immediately behind the boll. As much as 15.6 *per cent.* of the Adio Ishan sheds had this particular type of lesion. The effect of such lesions, as a defoliating factor, when on the leaf petiole has already been instanced.

It seems that, of these two main fungoid factors producing shedding (excluding *Nematospora gossypii* which has been dealt with elsewhere), bacterial disease is the more important in open country, and *Alternaria* in the more humid forest zone.

(5). General Conclusions on Native Boll Shedding.

While the total percentage of flowers subsequently shed is affected by environmental factors it is also largely affected by the amount and extent of the damage to the bolls themselves by insects and fungoid diseases.

These diseases vary in potency as abscission-causing factors. Bacterial disease and *Alternaria* are very potent, and bollworm damage causes a large amount of shedding, especially of the younger bolls; on the other hand stainer damage does not have a very marked effect on the number of bolls shed unless the bolls are infected with internal boll disease through the punctures.

As was suggested by Mason and Wright (11, 1925) it is probable that the amount of shedding is affected by damage to the plant body by insects and fungoid diseases and also by the soil moisture conditions.

Ishan and Meko cottons exhibit similar features, the principal difference being the higher percentage of bolls shed on the Ishan cotton.

C.—Increase of Susceptibility to Shedding.

As will be seen from Table No. 39 there was a progressive increase in the percentage of flowers subsequently shed during the main period of boll production on all the plots, but in most cases there was a slight drop at the close of the season.

This gradual increase agrees with that found by Mason (9, 1922) in the West Indies for Sea Island Cotton, and which he correlated with the cessation of growth in the main axis that took place at the same time. The growth measurements taken during the present season do not, unfortunately, cover the period of the final drop in the percentage of flowers subsequently shed.

IX.—MUMMIED BOLLS.

The term " mummied " was applied by Mason and Wright (11, 1925) to " bolls in which the abscis layer was not complete, but which had dried up before attaining half their full size." The present writers experienced some difficulty in determining whether dried up bolls were less than half their full size, and applied the term " mummied " to bolls in which the abscis layer was not complete, but which had dried up before attaining their full size. All mummied locks are included in an analysis of the factors which caused damage to the locks of harvested bolls, the results of which are given later in this paper, *see* Table No. 40.

As green bolls on the plants were examined weekly, lesions on the carpel walls were noted prior to the commencement of mummification. In only one previous investigation (4) has information been given as to the causative factors of mummification and this was based on the examination of bolls only after mummification.

Table No. 27 shows the percentage of bolls (which subsequently mummied) bearing lesions of various kinds.

TABLE No. 27.

Locality and variety.	No. of mummied bolls examined.	% Bug Punctures.	% Boll-worm holes.	% Boll-worm scores.	% Bacterial.	% Anthracnose.	% Alternaria.	% Without lesions.
M. P. Allen	39	49	25	25·5	0	0	0	2·5
Adio „	39	58	10	29·5	0	0	0	2·5
M. P. Ishan	36	68	7	15	8	2	0	0
Adio „	16	51	13	24	8	0	4	0
M. P. Meko	32	67	5	18	4	0	0	6
Adio „	28	64	14	19	3	2	2	7

Although the number of mummied bolls dealt with was rather small, there is no doubt that bug punctures are the commonest type of lesion found on green bolls which subsequently mummify. Further evidence of this was obtained in the 1926-27 season by an examination of 100 mummied Ishan bolls, 49.5 *per cent.* of which bore recognisable bug punctures.

In Table No. 28 is shown the average age in days from anthesis to mummification, and the average period in days between the appearance of the first bug puncture on green bolls and subsequent mummification of the bolls.

TABLE No. 28.

Locality and variety.	Average age : anthesis to mummification.	Average period : Bug puncture to mummification.
M. P. Allen	31·2	21·4
Adio „	36·1	23·6
M. P. Ishan	43·1	31·8
Adio „	47·4	32·8
M. P. Meko	42·5	32·9
Adio „	51·7	37·7

In two cases, *viz.*, M.P. Allen and Meko, it was found that the average age from anthesis to mummification increased throughout the season, but the number of bolls concerned was small, and further data are required on this point.

With regards to *Alternaria* there was no evidence that this fungus, acting alone, was responsible for any mummification of bolls and its pathogenity appears to be limited to the plant body and to young bolls on native cotton plants in humid conditions.

X.—EXAMINATION OF THE DEVELOPING GREEN BOLLS ON THE PLANTS.

A.—Progress of Insect Attacks.

The weekly examination of the green bolls yields data from which can be calculated the period during which the developing bolls suffered most from the attacks of insects and fungoid diseases and in the cases of stainer and bollworm injury these figures can be compared with the repopulation figures obtained from the two gauges. But since the amount of damage to the green bolls on all the varieties grown on the Plantation was extremely great the counts of weekly increase of stainer punctures and bollworm lesions cannot be relied upon as being very accurate so that only the figures obtained from the Adio plot will be considered here.

Tables Nos. 29, 30 and 31 give the weekly increases in the number of stainer and bollworm lesions on all green bolls per acre, for the three varieties.

TABLE No. 29.

Adio Allen.

Week ending.	No. of green bolls × $\frac{1}{100}$	Weekly increase Bollworm holes × $\frac{1}{100}$.	No. of Boll-worms.	Weekly increase Stainer punctures × $\frac{1}{100}$.	No. of adult Stainers.	No. of Stainer nymphs and adults.	No. of new punctures per boll.
Sept. 26th	69	0	0	46	32	32	0·7
Oct. 3rd	183	3	0	155	272	272	0·8
„ 10th	337	15	616	644	936	936	1·9
„ 17th	583	64	616	678	1,232	1,232	1·2
„ 24th	830	43	1,848	1,013	728	728	1·2
„ 31st	1,047	101	1,222	1,337	2,200	2,200	1·3
Nov. 7th	1,200	213	2,260	2,590	1,496	1,528	2·2
„ 14th	1,233	151	2,618	3,416	1,424	1,440	2·8
„ 21st	1,371	262	—	3,151	448	520	2·3
„ 28th	1,180	169	—	4,374	168	680	3·7
Dec. 5th	1,020	123	—	1,522	40	416	1·5
„ 12th	836	154	—	1,272	88	712	1·5
„ 19th	660	59	—	1,032	16	440	1·6
„ 26th	545	31	—	456	104	284	0·8
Jan. 2nd	398	52	—	416	64	184	1·0
„ 9th	383	34	—	101	136	176	0·3
„ 16th	360	15	—	86	120	160	0·2
„ 23rd	297	6	—	28	88	208	0·1
„ 30th	240	3	—	—	96	216	—

First boll opened—November 3rd.

TABLE No. 30.

Adio Ishan.

Week ending.	No. of green bolls × $\frac{1}{100}$.	Weekly increase Bollworm holes. × $\frac{1}{100}$.	No. of Boll-worms.	Weekly increase Stainer punctures; × $\frac{1}{100}$.	No. of adult Stainers.	No. of Stainer nymphs and adults.	No. of new punctures per boll.
October 31st ...	212	0	0	6	664	664	0·03
November 7th...	512	0	0	170	1,088	1,088	0·3
.. 14th...	798	9	212	664	432	448	0·8
.. 21st ...	1,047	21	—	1,688	376	480	1·6
,, 28th...	1,310	9	—	2,185	112	296	1·7
December 5th...	1,453	15	—	2,857	48	456	2·0
.. 12th...	1,432	39	—	3,203	120	712	2·2
.. 19th...	1,406	48	—	3,127	240	832	2·2
,, 26th...	1,325	51	—	1,421	312	760	1·1
January 2nd	1,127	30	—	912	112	312	0·9
.. 9th...	899	30	—	589	96	208	0·7
.. 16th...	706	27	—	927	88	248	1·3
.. 23rd	537	42	—	533	64	552	1·0
,, 30th...	392	54	—	260	192	712	0·7
February 6th...	179	24	—	124	—	—	0·7

First boll opened—December 4th.

TABLE No. 31.

Adio Meko.

Week ending.	No. of green bolls × $\frac{1}{100}$.	Weekly increase Bollworm holes. × $\frac{1}{100}$.	No. of Boll-worms.	Weekly increase Stainer punctures. × $\frac{1}{100}$.	No. of adult Stainers.	No. of Stainer adults and nymphs.	No. of new punctures per boll.
October 17th...	51	0	0	3	40	40	0·06
,, 24th...	164	0	0	7	40	40	0·04
,, 31st ...	386	0	0	33	688	688	0·1
November 7th...	722	36	106	766	536	536	1·1
,, 14th...	1,094	6	424	1,167	344	344	1·1
,, 21st ...	1,382	23	—	1,509	184	472	1·1
,, 28th...	1,644	16	—	2,044	136	224	1·2
December 5th...	1,787	20	—	2,328	80	504	1·3
,, 12th...	1,850	33	—	2,520	104	400	1·4
,, 19th...	1,846	33	—	2,002	104	488	1·1
,, 26th...	1,685	33	—	2,233	8	208	1·3
January 2nd	1,451	29	—	1,327	104	352	0·9
,, 9th...	1,089	46	—	916	128	224	0·8
,, 16th...	847	42	—	681	32	96	0·8
,, 23rd	574	59	—	280	56	160	0·5
,, 30th...	403	36	—	372	112	280	0·7
February 6th...	249	10	—	91	—	—	0·4
,, 13th...	170	3	—	—	—	—	—

First boll opened—November 28th.

In considering the above three tables two features have to be taken into account. After the dates given below each table for the opening of the first boll, open bolls were available for the stainers for food, so that the number of punctures on the green bolls do not, after these dates, represent the number of times that the stainers have fed. It has also to be remembered that the figures shown for the numbers of stainers and stainer nymphs are those obtained from the stainer index and are not the true population figures but the weekly rate of re-population, in spite of this fact the weekly increases of stainer punctures agree fairly well with the number of stainers present, but it is impossible to determine the average number of punctures per stainer.

In the above three tables the column showing the number of new punctures per boll represents the intensity of the stainer attack. In the case of all three cottons the times of maximum intensity of stainer attack and maximum number of green bolls per plant agree very closely, so that the greatest amount of damage by stainers per boll occurred at the time when the greatest number of bolls were developing. With the Allen this was two weeks before the maximum picking and with the two native cottons four weeks.

B.—The effect of the Time of Initial Injury to Bolls on extent of Damage caused by Internal Boll Disease.

It was thought that the time of the initial injury to any boll might have considerable effect on the extent of the ultimate damage caused by internal boll disease introduced through injury. All harvested bolls were therefore divided into the three classes given below and it was determined during which week in their development the majority of the bolls in each class were first subject to injury. It was found, however, that the time of the initial damage did not effect the extent of the boll rot and the detailed analysis is only given for the Adio Allen (Table No. 32) where it will be seen that the highest percentage of bolls of all classes was damaged in their second week of development.

TABLE No. 32.

Adio Allen.

	No. examined.	% Damaged in				
		1st week.	2nd week.	3rd week.	4th week.	5th week. & after.
Bolls not infected with I.B.D.	204	28	44	15	5	7
Bolls with locks stained by I.B.D.	75	25	48	17	7	5
Bolls with locks made useless by I.B.D.	81	23	46	22	7	1

With the two native varieties a difference was found between the bolls infected with internal boll disease and those not so infected, but not between the two degrees of infected bolls.

TABLE No. 33.

Adio Ishan.

	No. examined.	% Damaged in				
		1st week.	2nd week.	3rd week.	4th week.	5th week. & after.
Bolls not infected with I.B.D.	306	30	31	13	6	20
Bolls infected with I.B.D.	41	54	32	10	5	0

Adio Meko

Bolls not infected with I.B.D.	405	26	35	17	7	14
Bolls infected with I.B.D.	65	29	48	11	9	3

In connexion with the above tables it cannot be presumed that the initial lesion was the origin of any later infection, since, as will be discussed in the next section the number of stainer punctures that caused infection by internal boll disease on the Adio plot was apparently very low. In general, however, the above figures indicate that if the developing boll escapes injury during its early stages it has a greatly enhanced chance of eventually producing good lint even though it may suffer severe damage in its later stages.

In this connexion it has been demonstrated, by inoculation experiments, that the specific fungus of internal boll disease, *Nematospora gossypii*, will not infect old cotton bolls even when treated with a spore suspension (5, 1927). This has been confirmed by Marsh (8, 1926) working on several varieties of cotton and he also states that the fungus has no power of destroying cellulose under experimental conditions.

C.—An Estimate of the Percentage number of Bug Punctures through which Internal Boll Disease was introduced to Bolls developing on the Adio Plot.

The following estimates are calculated from the figures available over the whole period in which bolls were developing; but it is probable that at certain periods the percentage is higher than at others.

In Tables Nos. 34 and 35 the harvested bolls have been divided into the classes shown, the first class being given only for comparison to show that bolls that yield clean lint have, very definitely been damaged by fewer stainer punctures than other bolls.

TABLE No. 34.

Adio Allen.

	No. examined.	Total number of punctures on Bolls.	Number of puncture per 100 Bolls.
I. Bolls with all locks good.	49	157	320
II. Bolls not infected with I. B. D. ...	200	1,544	772
III. Bolls infected with I. B. D.	190	1,779	936

In inserting the following argument the writers do not desire to emphasise the precision of the results derived since there are several unknown factors, such as the number of times that the individual stainer may puncture the same boll, that may introduce considerable error, but the results obtained from the three cotton varieties do agree very closely for the one locality.

Taking Adio Allen for example :—

From Table No. 34 above it will be seen that on 200 bolls (II) there have been 1,544 uninfected punctures, *i.e.*, punctures through which internal boll disease has not been introduced. Then presumably on 190 bolls (III) there have been $\frac{1,544 \times 190}{200} = 1,466$ uninfected punctures and therefore $1,779 - 1,466 = 313$ infected punctures. Therefore on 390 bolls (200 + 190) with 3,323 punctures (1,544 + 1,779) only 312 punctures are infected, *i.e.*, 9.4 *per cent.*

The Ishan and Meko figures are obtained similarly.

TABLE No. 35.

ADIO ISHAN AND MEKO.

	No. examined.		Total number of punctures on Bolls.		Number of punctures per 100 Bolls.	
	Ishan.	Meko.	Ishan.	Meko.	Ishan.	Meko.
I. Bolls with all locks good.	114	146	1,126	1,323	988	906
II. Bolls not infected with I. B. D. ...	284	358	3,540	3,348	1,246	935
III. Bolls infected with I. B. D.	37	53	999	963	2,700	1,815

TABLE No. 36.

PERCENTAGE OF INFECTED PUNCTURES.

Adio Allen	9·4
Ishan	11·9
Meko	10·8

From Table No. 35 it will be seen that for each of the three classes of bolls there are more punctures per 100 Ishan bolls than per 100 Meko bolls, and the number of stainers on the Ishan at Adio was also greater than on the Meko. The proportion of stainers on Meko to those on a similar area of Ishan and Allen is 1 :1.5 :2.3 while

the proportion of punctures on an equal number of bolls from comparable samples of Meko, Ishan and Allen is 1:1.2:0.7. The apparent discrepant figures of the Allen may be explained by the hypothesis that the stainers are more satisfied through a single puncture on an Allen boll than on a native boll of either variety; it cannot be explained by supposing that the proportion of stainers per boll is any less on the Allen since this is not borne out by the figures shown in Table No. 29.

XI.—COMPARISON OF STAINER INCIDENCE AND INSECT DAMAGE TO GREEN BOLLS ON NATIVE COTTON GROWN ALONE AND ON NATIVE COTTON GROWN NEAR ALLEN.

As stated above the experimental plots on Moor Plantation and at Adio consisted of alternating sub-plots of Allen, Ishan and Meko with the object of avoiding, as far as possible, soil variations; but it was realised that there were certain disadvantages in the adoption of this method of planting, *viz.*, a possible increased infestation of insects on the native varieties resulting from the proximity of Allen cotton.

In order to obtain some information on the extent of this increase, estimations of the number of insect lesions on green bolls of Meko and Ishan grown alone on Moor Plantation were made, and a comparison was made between these numbers and those on native green bolls in the experimental plot in the same locality. In addition a stainer index was carried out on Meko grown alone and the infestation was compared with that on Meko in A.6.S.

Table No. 37 shows the average number of insect lesions per green boll on native cottons grown alone and with Allen, all plots being on Moor Plantation.

TABLE No. 37.

Date examined.	Variety of cotton.	Remarks.	Average No. Bug punctures.	Average No. Bollworm lesions.
29 December, 1925	Meko	Grown alone.	16·5	1·2
	,,	With Allen	19·5	0·4
6 January, 1926 ...	Ishan	Grown alone.	7·9	0·8
	,,	With Allen	19·8	0·7

It appears that Allen cotton is so attractive to bollworms that the presence of this variety actually results in a slight decrease in the

damage to native varieties planted near it as compared to native cotton grown alone. On the other hand the number of bug punctures is noticeably greater on native cottons grown near Allen.

Table No. 38 shows the number of adult stainers collected in eight weeks between September 13th, and November 7th and in five weeks between November 8th and December 12th on Meko grown alone and with Allen, also the percentage of each species of *Dysdercus* in the whole period on the two plots.

TABLE No. 38.

Number of adults collected.	Meko grown alone.	Meko grown with Allen.
From September 13th, to November 7th	842	982
From November 8th, to December 12th	658	2,120
Total	1,500	3,102
% *D. superstitiosus*—Spotted form	87·1	54·8
% *D. superstitiosus*—Banded form	3·3	3·4
% *D. melanoderes*	9·3	41·4
% *D. fasciatus*	0·3	0·4

There was concordance between the infestation on the two plots for the first eight weeks of the cotton season, but after November 7th the number of stainers taken weekly on Meko grown with Allen was markedly greater, and from observation this increase was even higher later in the season. The bulk of the Allen crop is harvested in December and there is little food available on that variety in January and February; the stainers consequently move onto the neighbouring sub-plots of native cotton, on which numbers of bolls are still being produced.

There is some evidence from stainer index figures over three years that *D. melanoderes* is relatively more numerous on Allen than on Meko, and the higher proportion of this species on Meko grown with Allen may be regarded as a further proof of diffusion from the Allen.

XII.—HARVESTED BOLLS.

The analysis of the harvested bolls yields the most important results in each survey since it demonstrates, quite definitely, which factors have inhibited the production of undamaged seed cotton by

bolls escaping abscission. A summary of the results of these analyses is given below and it will be seen that there is some variability in the proportions of stainer and bollworm damage to locks.

A.—(1) Allen.

In ten out of thirteen surveys the number of locks damaged by stainer (internal boll disease) has exceeded that damaged by bollworms, but perhaps more important than this is the fact that, whenever the percentage of damaged locks has been exceptionally large the number damaged by stainers has been correspondingly great and far in excess of that damaged by bollworms.

(2) Meko.

In only four out of twelve surveys has stainer damage exceeded bollworm damage; in two of these four surveys the Meko was planted contiguous to Allen and the remaining two were carried out on Moor Plantation in the vicinity of comparatively large areas of Allen cotton. In these four cases the percentage of damaged locks was exceptionally great.

(3) Ishan.

Figures are available for only four surveys on Ishan cotton; in each case stainer damage exceeded bollworm damage, but twice the Ishan was contiguous to Allen and once was near large areas of that variety.

For all varieties the highest figures for stainer damage occurred on plots on Moor Plantation. There seems little doubt that, where a poor crop has been obtained, the most serious inhibiting factor has been the cotton stainer.

The method adopted of grading the locks of harvested bolls has already been described fully in the section of this paper dealing with experimental methods, and need not be repeated here.

For each variety of cotton, the history of the flowers produced each fortnight was followed out, the number of bolls ultimately shed, mummied or harvested being determined. In addition the locks from harvested bolls (derived from flowers produced in each fortnightly period) were analysed.

The percentages of shed, mummied and harvested bolls from the flowers produced fortnightly, and the lock analysis of harvested bolls are shown in Table No. 39.

TABLE No. 39.

Locality and Variety.	Flowers produced fortnight ending.	No. of flowers produced per acre × 1/100.	% Shed.	% Mummied.	% Harvested.	Locks harvested fortnight ending.	No. of locks harvested per acre × 1/100.	% Good.	% Fair and Matted.	% With I.B.D.	% Bollworm.	% Bacterial.
M.P. Allen.	Sept. 26th ...	298	57	11	32	Nov. 14th ...	381	2	18	61	15	0
	Oct. 10th ...	926	50	7	43	„ 28th ...	1,640	13	23	57	6	0
	„ 24th ...	1,426	55	5	40	Dec. 12th ...	2,298	13	21	56	7	0
	Nov. 7th ...	1,421	80	8	12	„ 26th ...	666	8	20	62	9	0
	„ 21st ...	310	84	4	12	Jan. 9th ...	146	1	20	63	16	0
	Dec. 5th ...	313	91	7	2	„ 23rd ...	25	6	0	94	0	0
	Totals ...	4,694	66	7	27	Totals ...	5,156	11	22	58	8	0
Adio Allen.	Sept. 26th ...	71	68	15	17	Nov. 14th ...	49	0	11	70	17	0
	Oct. 10th ...	396	65	5	30	„ 28th ...	480	5	31	45	16	0
	„ 24th ...	838	65	4	31	Dec. 12th ...	1,026	23	29	37	9	0
	Nov. 7th ...	1,118	71	3	26	„ 26th ...	1,164	37	28	22	11	0
	„ 21st ...	866	73	7	20	Jan. 9th ...	685	44	22	15	10	0
	Dec. 5th ...	443	71	4	25	„ 23rd ...	420	56	21	5	12	0
	„ 19th ...	191	63	0	37	Feb. 6th ...	262	43	24	4	23	0
	Totals ...	3,923	69	4	27	Totals ...	4,086	33	27	25	12	0
M.P. Ishan.	Sept. 26th ...	11	20	20	60	Nov. 14th ...	20	15	10	40	5	15
	Oct. 10th ...	125	31	6	63	„ 28th ...	236	22	6	41	6	23
	„ 24th ...	708	45	5	50	Dec. 12th ...	1,108	18	17	42	3	14
	Nov. 7th ...	1,289	44	6	50	„ 26th ...	2,001	11	8	63	3	9
	„ 21st ...	913	48	8	44	Jan. 9th ...	1,275	7	10	64	5	12
	Dec. 5th ...	633	52	11	37	„ 23rd ...	673	16	10	53	7	10
	„ 19th ...	322	37	9	54	Feb. 6th ...	532	47	11	16	6	12
	Jan. 2nd ...	227	25	12	63	„ 20th ...	437	72	5	1	9	8
	Totals ...	4,228	45	7	48	Totals ...	6,282	20	10	49	5	11
Adio Ishan.	Oct. 24th ...	82	57	0	43	Dec. 12th ...	108	51	13	22	1	4
	Nov. 7th ...	549	41	3	56	„ 26th ...	950	59	17	12	6	3
	„ 21st ...	837	53	2	45	Jan. 9th ...	1,170	68	13	8	5	3
	Dec. 5th ...	856	57	2	41	„ 23rd ...	1,092	62	17	4	15	1
	„ 19th ...	396	65	3	32	Feb. 6th ...	387	58	10	1	21	3
	Jan. 2nd ...	60	49	9	42	„ 20th ...	79	57	8	0	20	7
	„ 16th ...	11	20	20	60	Mar. 6th ...	19	61	17	0	11	0
	Totals ...	2,791	53	3	44	Totals ...	3,805	62	14	7	10	2
M.P. Meko.	Sept. 26th ...	18	29	0	71	Nov. 14th ...	39	16	16	43	10	15
	Oct. 10th ...	165	19	3	78	„ 28th ...	400	16	11	42	7	21
	„ 24th ...	668	33	4	63	Dec. 12th ...	1,290	13	12	49	6	14
	Nov. 7th ...	871	38	3	59	„ 26th ...	1,590	7	8	63	5	11
	„ 21st ...	622	36	6	58	Jan. 9th ...	1,126	3	4	79	3	10
	Dec. 5th ...	378	35	14	51	„ 23rd ...	602	14	10	61	8	6
	„ 19th ...	255	30	7	63	Feb. 6th ...	497	42	10	28	8	5
	Jan. 2nd ...	265	21	13	66	„ 20th ...	538	67	9	4	12	2
	Totals ...	3,242	33	6	61	Totals ...	6,082	17	9	53	6	10
	Oct. 10th ...	6	50	0	50	Nov. 28th ...	10	11	33	22	33	—
	24th ...	178	37	4	59	Dec. 12th ...	318	32	30	23	11	—

Adio Mel	Nov.	7th	...	678	29	3	68	,,	20th	...	1,329	52	24	15	9	
	,,	21st	...	887	44	5	51	Jan.	9th	...	1,402	51	29	12	5	
	Dec.	5th	...	792	50	5	45	,,	23rd	...	1,100	49	30	5	14	
	,,	19th	...	436	60	5	35	Feb.	6th	...	462	52	24	1	21	
	Jan.	2nd	...	106	59	9	32	,,	20th	...	105	50	19	1	22	
	,,	16th	...	19	61	6	33	Mar.	6th	...	20	17	33	0	17	
	Totals		...	3,102	45	4	51	Totals		...	4,842	49	28	10	9	--

The decrease in the percentages of locks infected by internal boll disease on all varieties at Adio reflects very closely the diminution in the number of stainers in that locality commencing in November (*see* Tables Nos. 29, 30 and 31). In the case of both native varieties on Moor Plantation the greatest percentages of locks infected by internal boll disease occurred on bolls harvested between December 13th and January 9th while the maximum adult stainer infestation was in the week ending November 14th on both these varieties. In the succeeding six weeks the percentage of internal boll disease infection on locks diminished on both native varieties; on the other hand the M.P. Allen produced almost all its crop before January 9th, and only the earliest green bolls escaped the severe stainer infestation in November and December.

The percentages of clean seed cotton to total yield for the six plots were as follows:—

M.A., 50; A.A., 77; M.I., 53; A.I., 88; M.M., 41; A.M., 76.

From these figures it appears that a late-flowering Ishan cotton would avoid, to a great extent, the maximum stainer infestation in a normal year; the 'harmattan' reduces the stainer population considerably in January and in February the spotted form of *superstitiosus* migrates to *Sterculia sp.* and *Bombax spp.* Mr. C. J. Lewin, Senior Botanist, has produced two strains of Ishan cotton, superior to Allen as regards lint qualities, which shed their early buds and produce their maximum number of flowers in December. There seems to be little doubt that these strains of improved Ishan, if grown in accordance with local custom, *i.e.*, in small areas and intercropped, would escape severe stainer attack.

B.—Nature of Bacterial Damage on Harvested Bolls.

A comparison has already been made with regards to bacterial leaf damage and boll shedding on Allen and Meko plants on Moor Plantation during three seasons and a parallelism was noted in so far as a steady diminution of damage due to this factor was observed in both cases. This does not hold good when bacterial damage to harvested locks is considered. The damage by this factor on Ishan and Meko plants on Moor Plantation is considerably higher than was the case in former investigations. The amount of bacterial damage on the developing and harvested bolls on special plants was carefully investigated and it was found that, of bolls which had bacterial lesions on their pericarp, 24.2 *per cent.* had, subsequently, no damage on their locks. This implies that the damage was only superficial and, possibly, bacterial saprophytes were responsible and gained entrance through insect lesions. Certainly, most of the bolls

with bacterial lesions had also lesions due to bugs or bollworms, or both.

It was also noted that a great proportion of bolls whose locks were damaged by bacteria had no lesions due to this factor, on the pericarp. Many such locks were also damaged by bollworms and when examined, microscopically, were found to be infected with bacteria of the cocci type. It is worth recording in this connexion that Hopkins (16, 1926) has isolated two bacteria which caused an internal rot of cotton bolls in the West Indies.

The amount of bacterial damage to locks must not be taken as an index of the activity of *Pseudomonas malvacearum* for it is very evident that other bacterial pathogens operated.

XIII.—DISCUSSION OF RELATIVE MERITS OF ALLEN, ISHAN AND MEKO.

Before discussing the comparative merits of the three varieties it is necessary to emphasise the fact that both native varieties suffered unduly from stainer attack as a result of their proximity to Allen cotton.

A.—Yield.

The harvesting of the two five acre plots (except the 240 special plants) was carried out by the Superintendent of Agriculture in charge of Moor Plantation, and comparisons of the yields of the three varieties have already been published (15, 1925, p. 94 and 95). On Moor Plantation the two native varieties yielded about $1\frac{1}{2}$ times as much seed cotton per acre as Allen, and at Adio over twice as much.

At Adio, although Meko yielded more heavily than Ishan, the percentage of clean seed cotton was only eighty-one on Meko as compared to ninety-three on Ishan (15, 1925, p. 80). Ishan gave the greatest yield of *clean* seed cotton per acre and also produced the highest percentage of good locks and the lowest of useless locks in both localities (*see* Table No. 40).

B.—Susceptibility to Insect and Fungoid Attack.

Ishan compares favourably with Meko as regards all the factors destructive to locks (*see* Table No. 40), but is more susceptible to the virus disease, leaf curl. Mr. Lewin has found that two strains of his improved Ishan exhibit a considerable degree of immunity to leaf curl (7, 1927), and this solitary objection to the recommendation of the improved Ishan as the most suitable cotton for the Southern Provinces of Nigeria is now removed.

TABLE No. 40.

		Allen.		Ishan.		Meko.	
		M.P.	Adio.	M.P.	Adio.	M.P.	Adio.
Flowers and Bolls Shed.	Flowers produced per acre	469,854	396,242	431,314	279,416	335,914	310,580
	% Shed	66·2	69·1	43·9	53·5	32·7	44·6
	„ Attacked by Bollworm	23·7	22·4	4·8	3·5	3·5	2·6
	„ „ „ Bugs	26·3	26·6	17·6	15·5	11·5	11·9
	„ „ „ Alternaria	—	—	1·9	6·2	2·1	5·0
	„ „ „ Pseudomonas	—	—	6·1	0·5	4·0	0·7
	„ „ „ Anthracnose	—	—	0·1	—	0·1	—
	„ Without any lesions	11·7	16·2	6·5	16·9	4·4	15·4
	„ Unclassified	4·5	4·1	6·9	10·9	7·1	8·9
Bolls Left on the Plant.	No. bolls remaining per acre	158,928	122,430	242,104	129,956	225,462	172,038
	% Remaining	33·8	30·9	56·1	46·5	67·3	55·4
	No. bolls mummied	30,492	17,402	32,118	7,420	21,412	14,310
	% Mummied	6·5	4·5	7·5	2·7	9·4	4·7
	„ *Good* locks	9·2	27·3	18·0	59·2	15·7	45·6
	„ *Fair* locks	9·1	19·9	10·3	18·2	8·4	25·5
	„ *Stained*	27·2	11·23	33·8	7·8	38·1	10·2
	„ „ by I.B.D.	26·7	10·8	31·2	5·3	36·3	8·2
	„ „ „ Pseudomonas and other Bacteria	—	0·03	1·9	0·8	1·2	0·4
	„ „ „ Bollworm	0·5	0·4	0·7	1·7	0·6	1·6
	„ *Useless* locks	53·3	39·35	34·0	12·2	35·2	17·1
	„ Rendered useless by Stainer and I.B.D.	27·2	22·5	13·9	3·7	15·7	5·1
	„ „ „ „ Pseudomonas and other Bacteria	—	0·05	8·7	1·3	8·9	1·7
	„ „ „ „ Bollworm	10·1	11·2	4·0	3·6	5·8	3·9
	„ „ „ „ Alternaria	—	—	—	0·2	0·01	0·3
	„ „ „ „ Anthracnose	—	—	—	0·1	0·6	0·2
	„ Useless locks unclassified	16·0	5·6	7·6	3·3	4·2	5·9
	„ Locks lost	1·1	2·0	3·7	2·6	2·0	1·7
	„ Clean seed cotton harvested	50·2	77·4	53·5	87·9	41·4	76·4
Yields.	Calculated from special plants—Total lbs. per acre	373	372	752	568	753	777
	Clean	187	288	402	499	312	594
	Dirty	186	84	350	69	441	183
	M.P. as harvested (Adio corrected) Total lbs. per acre	286	248*	432	533*	436	572*
	Clean	132	176	259	496	179	463
	Dirty	154	72	173	37	257	109

* Corrections on Adio plot for shade. * (+ 63) * (+ 148) * (+ 159)

XIV.—CLOSE SEASON MEASURES.

In 1923 it was determined to endeavour to control *Dysdercus*, on an experimental scale, by the eradication of the principal food plants in an area of nine square miles having Moor Plantation as its centre. In that year all silk cotton trees were destroyed, standing cotton and *Hibiscus esculentus* were uprooted. In 1924 and 1925, standing cotton was uprooted in April and farmers in the area were instructed not to plant either *H. esculentus* or *H. sabdariffa;* in addition the majority of plants of the following three species were uprooted—*Hibiscus vitifolius*, *Urena lobata* and *Abutilon zanzibaricum*.

As stated above, one of the objects of the present experiment was to make a comparison of insect factors within and outside the close season area; stainer and bollworm incidence (determined by means of gauges described above) and the percentage insect damage to harvested bolls has been utilised for comparative purposes in this connexion.

In Table No. 41 is shown the percentage damage due to bollworms and to stainers in conjunction with *Nematospora* sp., obtained by the writers in 1925-26 and by other workers in 1924-25.

TABLE No. 41.

1924–25. Surveys No. 2 and 3 b.	Allen.		Ishan.		Meko.	
	% damage to open bolls caused by:					
Locality.	Internal Boll Disease and Stainer.	Boll-worm.	Internal Boll Disease and Stainer.	Boll-worm.	Internal Boll Disease and Stainer.	Boll-worm.
Moor Plantation ...	20	10	...	...	23	14
Oyo	21	12	...	...	7	15
Ilugun	11	20	...	...	3	19
1925–26. Present Survey.						
Moor Plantation ...	54	11	45	5	52	6
Adio	33	12	11	5	13	5·5

N.B.—The Oyo plots were between forty and fifty miles north north-east of Moor Plantation the Ilugun plots about twenty miles west south-west and the Adio plot about four miles due west.

For convenience, the effects of the close season measures on stainer and bollworm incidence are considered separately below.

A.—Stainer Incidence and Damage.

The stainer index (*see* Table No. 1) proved that stainers were far more numerous on all varieties on Moor Plantation than on the same varieties at Adio, and, with one exception, this was reflected in the damage percentages (over two years) just tabulated. A series of flight experiments with *Dysdercus*, carried out in 1924 (1, 1925), proved that stainers could fly a distance of one mile in less than eighteen hours and that, therefore, the close season area was not sufficiently extensive to effect an efficient control on *Dysdercus*.

B.—Bollworm Incidence and Damage.

The bollworm gauge (*see* Table No. 3) showed that there was a greater infestation on Moor Plantation than at Adio in 1925, although the percentage damage to open bolls was practically identical in both localities in that year, probably on account of the larger number of bolls remaining on the Moor Plantation plants. The 1924-25 damage figures for both Allen and Meko are lower on the Plantation than at Oyo and Ilugun, but the evidence as a whole indicates that the close season measures have had little, if any, controlling effect on bollworm incidence on Moor Plantation.

The difficulties encountered in the eradication of food plants in an area of only nine square miles were so great, chiefly on account of the dense vegetation, that an efficient application of close season measures on a large scale in the Southern Provinces of Nigeria would be impossible. Even if conclusive evidence had been obtained of a diminution in insect incidence in the close season area, the writers would have hesitated to recommend the adoption of a control method involving very considerable expenditure and which was obviously impracticable on account of local conditions.

XV.—MAIN CONCLUSIONS.

A detailed survey was made of the factors inhibiting the development of Allen, Ishan and Meko cottons grown on Moor Plantation, Ibadan, and at Adio in forest country four miles to the west of the first-named locality. The main conclusions drawn from the data obtained from this survey are as follows:—

(*a*) Both Ishan and Meko gave considerably higher yields than Allen. Of the two native varieties, Ishan was less subject to all diseases except leaf curl and gave a higher yield of *clean* seed cotton than Meko.

[*N.B.*—The improved strains of Ishan, bred by Mr. Lewin, are not only superior to Allen and Meko in lint qualities, but, in two cases, exhibit a considerable degree of immunity to the virus diseases, leaf curl.]

(*b*) The close season measures, carried out from 1923 to 1925, in an area of nine square miles surrounding Moor Plantation, were completely ineffective as a control for cotton stainers, and had little, if any, controlling effect on bollworms. Although flight experiments with stainers (in 1924) showed that the area was too small, the application of close season measures on a large scale in Southern Nigeria is regarded as impracticable on account of local conditions and expenditure.

(*c*) A late-flowering cotton would avoid, to a large extent, heavy stainer infestation in a normal year. The Ishan strains exhibiting this characteristic (bred by Mr. Lewin) will, in all probability, suffer little from stainers—the most important factor inhibiting the development of cotton in Southern Nigeria.

ACKNOWLEDGMENTS.

In conclusion the writers wish to record their indebtedness to Mr. C. J. Lewin, Mr. G. W. Lines, Mr. E. H. G. Smith, Mr. G. H. Jones and Mrs. F. D. Golding for their valuable help.

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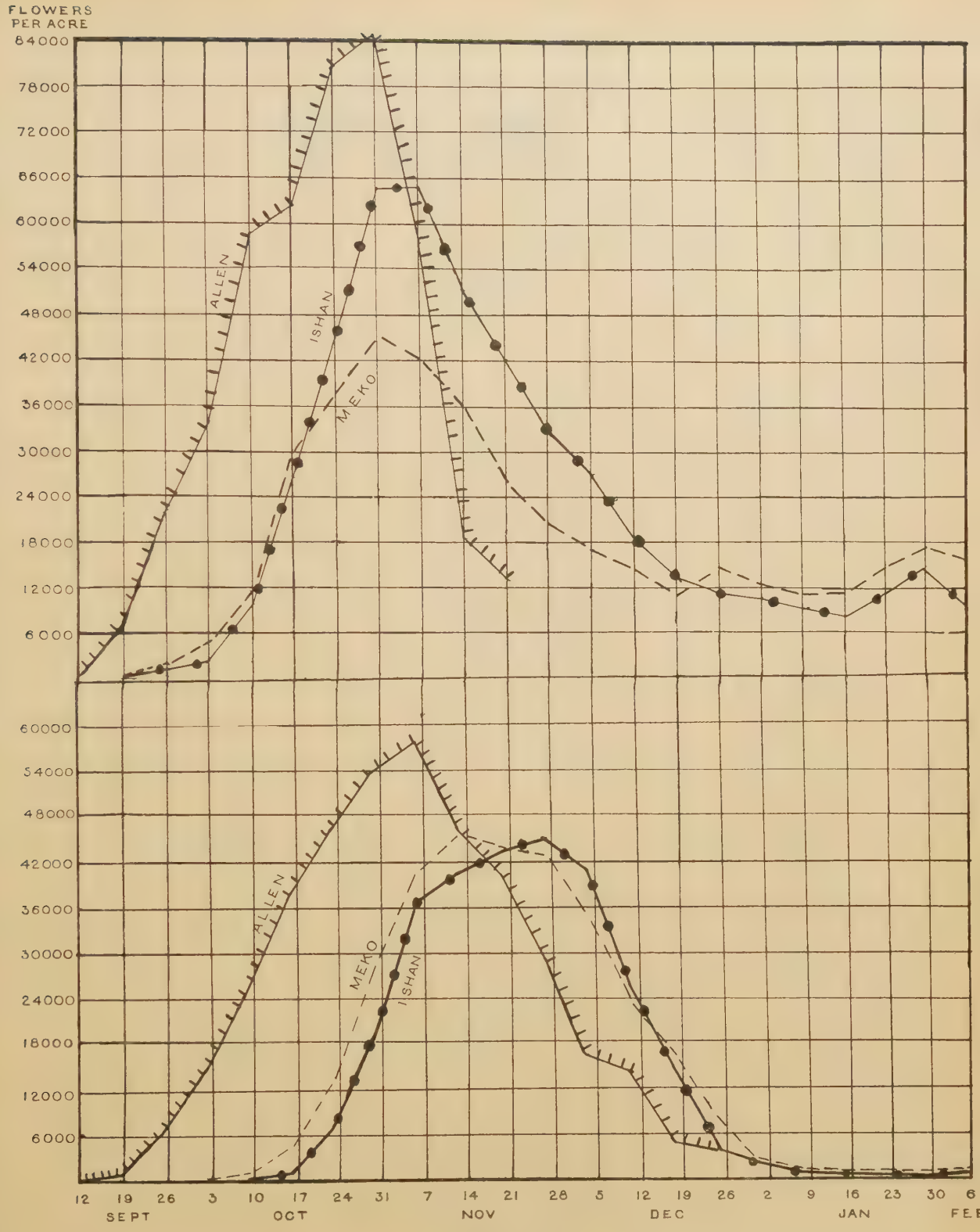

CHART NO. 1.

Showing the flowering curves of three varieties of cotton in two localities.

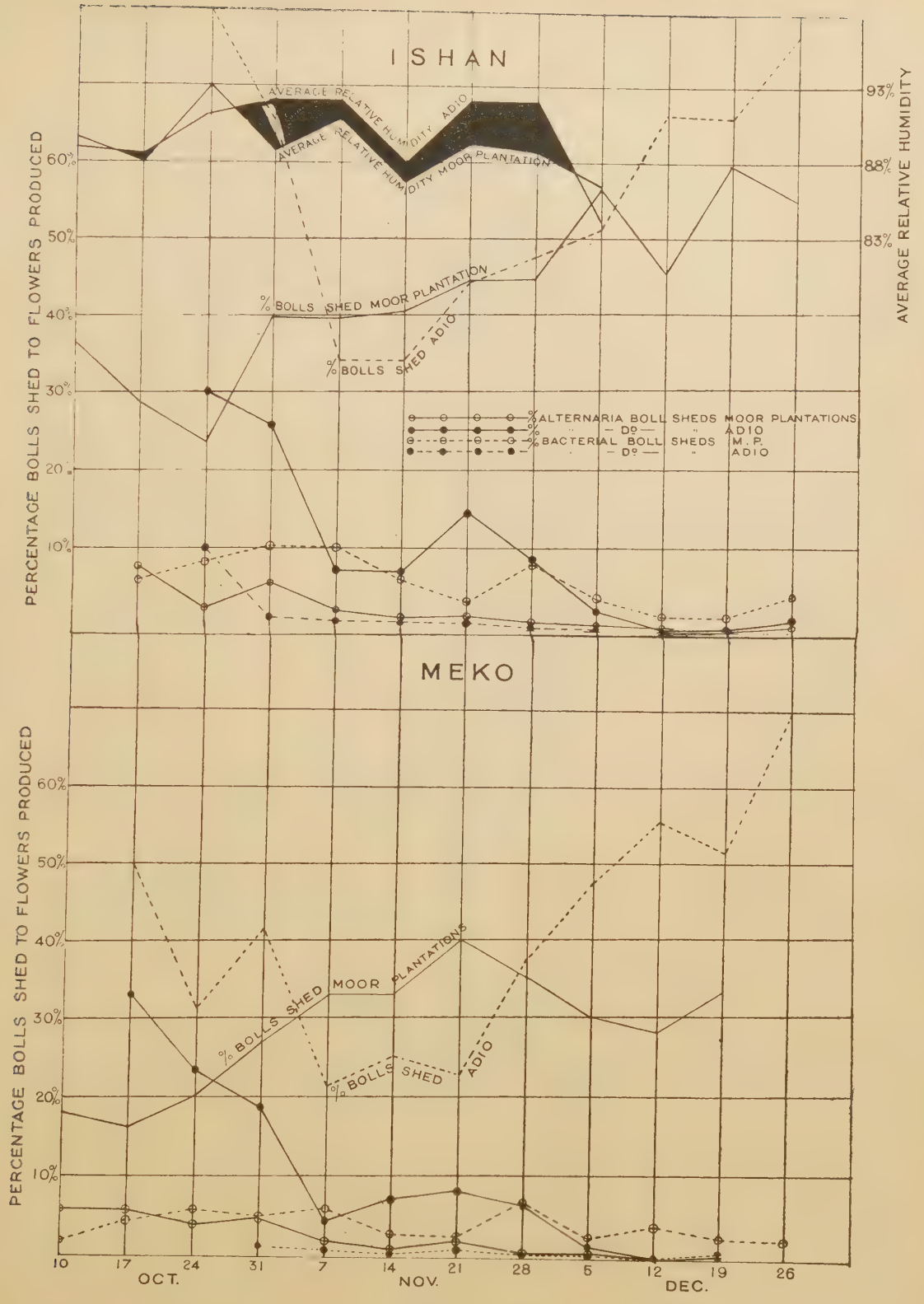

CHART NO. 2.

Showing (a) percentage boll sheds on Ishan and Meko varieties of cotton at Moor Plantation and Adio (b) percentage boll sheds due to *Alternaria* and *Pseudomonas malvaccarum* and (c) Correlation between boll shedding due to *Alternaria* sp. and the relative humidity on both plots.

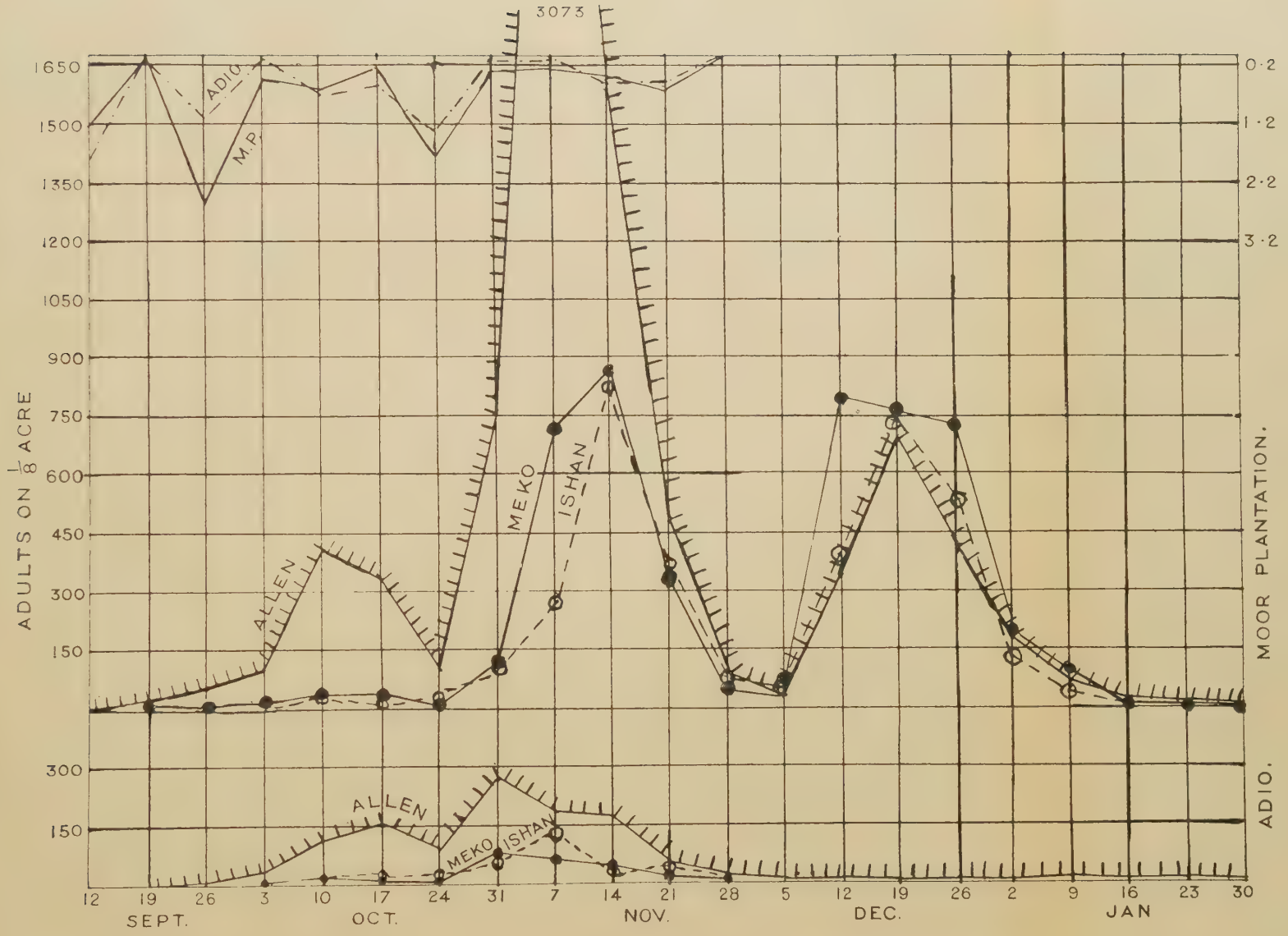

CHART NO. 3.

Showing number of adult stainers (of all species) occurring weekly on $\frac{1}{8}$ acre of Allen, Meko and Ishan in two localities.

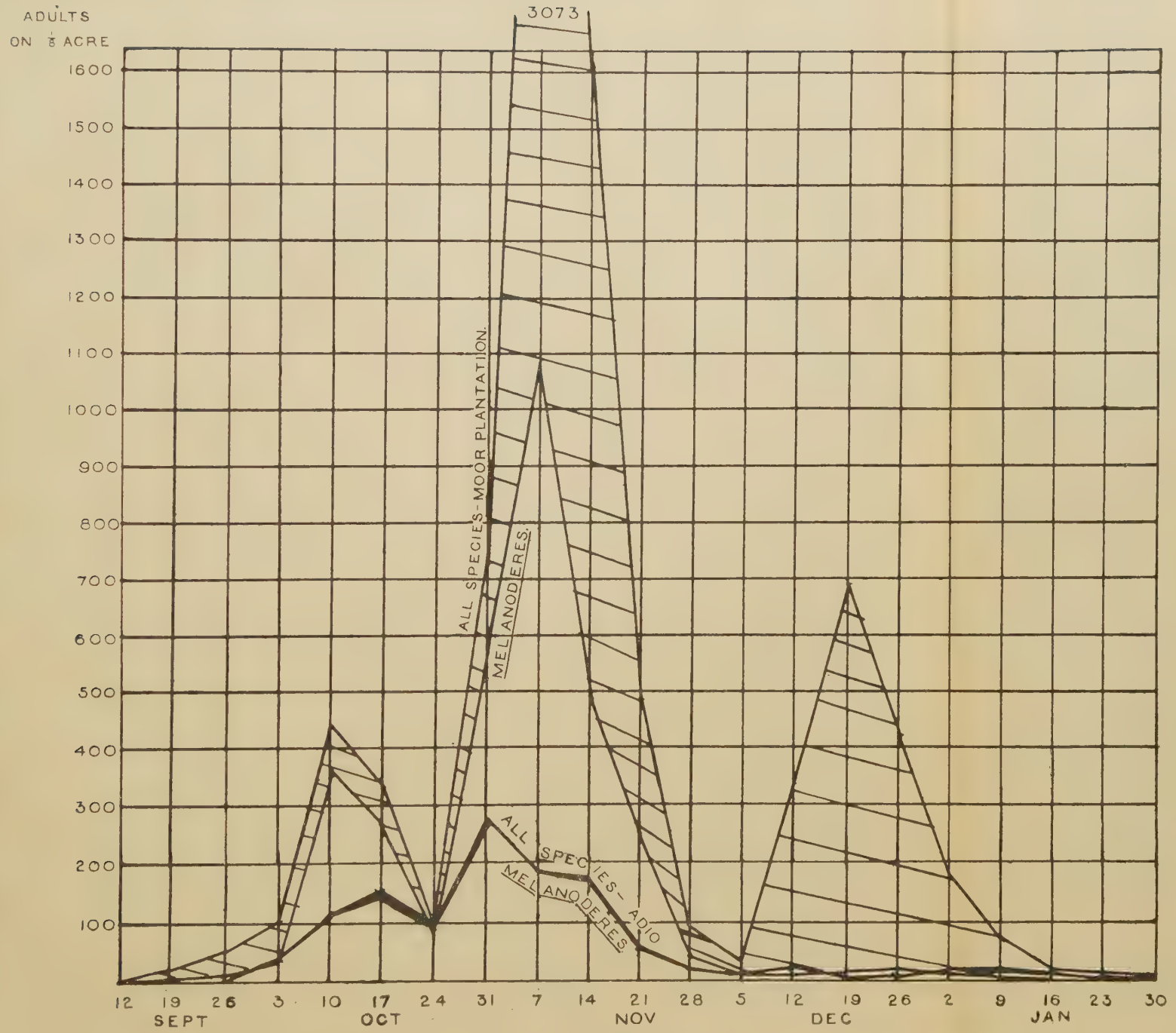

CHART NO. 4.

Showing proportion of *D. melanoderes* adults to total adults occurring weekly on ⅛ acre of Allen at Adio and on Moor Plantation.

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APPENDIX No. I.

LIST OF INSECT PESTS OF COTTON IN NIGERIA.

Name of Pest.	Status.	Parasites.	Predators.
(A) ATTACKING THE GREEN BOLLS.			
Pyrrhocoridae.—		*Tachinidae.*	*Reduviidae.*
Dysdercus superstitiosus, Fab.	Major	Epineura rubens, Vill.	Phonoctonus.
D. melanoderes, Karsch. ...	„	Bogosiella pomeroyi, Vill.	picturatus, Fairm.
D. fasciatus, Sign.	„		P. formosus, Dist.
D. intermedius, Dist.	Minor	Allophora multisetosa, Vill.	P. lutescens G. & P.
D. ? ugandanus, Schout. ...	„		
D. nigrofasciatus, Stal. ...	„	A. nigeriensis, Vill.	
Noctuidae.—			
Diparopsis castanea, Hmps. ...	Major		
		Braconidae.	*Eumenidae.*
Earias biplaga, Walk.	„	? Microgaster sp.	Rhynchium
E. insulana, Boisd.	„	? Urogaster sp.	ventrale, Sauss.
		Ichneumonidae.	
		? Mesostonus basimacula, Cam.	
Prodenia litura, F.	Minor	*Braconidae.*	
Heliothis obsoleta, F.	„	*Tachinidae.*	
Eucosmidae.—			
Argyroploce leucotreta, Meyr.	Major	Egg parasite.	
		Braconidae.	
		Chelonus, sp.	
Pyralidae —			
Mussidia nigrivinella, Rag. ...	Minor		
Pentatomidae.—			
Nezara viridula, L.	„		
Aspavia armigera, F.	„		
Cetoniidae.—			
Pachnoda cordata, Drury. ...	„		
Diplognatha gagates, Forst. ...	„		
(B) ATTACKING THE OPEN AND DRIED BOLLS.			
Lavernidae.—		*Chalcidae.*	
Pyrocerces simplex, Wlsm. ...	Minor	Chalcis olethrius,	
P. coriacella, Snell.	„	Waterston.	

APPENDIX No. I—*continued.*

Name of Pest.	Status.	Parasites.	Predators.
Gelechiadae.—			
Mometa zemiodes, Durr. ...	Minor		
Lyonetiidae.—			
Plemyristis oenochares, Meyr...	,,		
Lygacidae.—			
Oxycarenus dudgeoni Dist. ...	,,		
O. gossypinus, Dist.	,,		
(C) ATTACKING THE ROOTS			
Eumolpidae.—			
Syagrus calcaratus, F.	Major	(occasionally).	
(D) ATTACKING THE STEM			
Buprestidae.—			
Pseudagrilus sophorae, L. ...	Minor		
Coccidae.—			
Pulvinaria jacksoni, Newst. ..	,,		
Lecanium inopheron, Laing. ...	,,		*Lycaenidae.*
(E) ATTACKING THE SHOOT.			
Capsidae.—			
Helopeltis bergrothi, Reut. ...	Major	(occasionally).	
H. sanguineus, Popp.	Minor	*Braconidae.* Euphorus nigricarpus, Szep.	*Syrphidae.* Xanthogramma pfeifferi, Big.

(F) ATTACKING THE LEAVES.		Parasites.
Lepidoptera.		
Nymphalidae.—		
Leucosticha daedalus, F. ...	Minor	
Liparidae.—		
Nygmia fasciata, Walk. ...	,,	
N. sp.	,,	
Lasiocampidae.—		
Leipoxais siccifolia, Auriv. . .	,,	
Limacodidae.—		
Parasa infuscata, Wied. ...	,,	
Lymantriidae.—		
Euproctis lyonia, Swinth. ...	,,	Braconidae, (2 spp.)

APPENDIX No. I—*continued.*

Name of Pest.	Status.	Parasites.
Lithosiidae.—		
Spilosoma maculosoma, Cram.	Minor	
Geometridae.—		
Nemoria stipolepida, Butl. ...	,,	
Noctuidae.—		
Cosmophila flava, F.	,,	Egg parasite.
Xanthodes graellsii, Feisth. ...	,,	
Phytometra chalcites, Esp. ...	,,	
Pyralidae.—		
Sylepta derogata, F.	Major	(occasionally).
		Ichneumonidae.
		Xanthopimpla punctata, F.
		Braconidae 2 Spp.
		Tachinidae.
		? Monella sp.
		Egg parasite.
Zebronia phenice, Cram. ...	Minor	
Tortricidae.—		
Cacoecia occidentalis, Wals. ...	,,	
Tineidae.—		
Acrocercops bifasciata, Wlsm.	,,	
Bucculatrix loxoptila, Meyr. ...	,,	
Psychidae.—		
Clania cervina, Druce	,,	
Arctidae.—		
Amsacta flavicosta, Hamps. ...	,,	
Coleoptera.		
Galerucidae.—		
Barombia humeralis, Laboiss.	,,	
Eumolpidae.—		
Eryxia holosericea, Klug. ...	,,	
Syagrus calcaratus, F.	,,	
Halticidae.—		
Nisotra uniforma, Jac.	,,	
N. ? dilecta, Dalm.	,,	
N. spadicea, Dalm.	,,	
Cryptocephalidae.—		
Cryptocephalus w-nigrum, Suff.	,,	
C. obesus, Suff.	,,	
C. bifasciatus, F.	,,	
C. simplex, Suff.	,,	

APPENDIX No. I—*continued.*

Name of Pest.	Status.	Parasites.
Lagriidae.		
Lagria villosa, F.	Minor	
L. viridipennis, F.	,,	
Buprestidae.—		
Pseudagrilus sophorae, F. ...	,,	
Agrilus capensis, Murray ...	,,	
Melolonthidae.		
Pseudotrochalus concolor, Kolbe	,,	
Curculionidae.—		
Siderodactylus sagittarius, Oliv.	,,	
Mitophorus acerbus Fst. ...	,,	
Rhynchota.		
Jassidae.—		
Empoasca facialis Jac.	Major	(occasionally).
Aphidae.—		
Aphis gossypii, Glov.	Minor	*Coccinellidae.* Chilomenes lunata, F. C. vicina, Muls. Hyperaspis pumila, Muls. *Syrphidae.* Paragus borbonicus, Mcq. P. longiventris, Bezzi. Syrphus ægypticus, Wied. S. nasutus, Maq. Xanthogramma pfeifferi, Big. *Hemerobiidae* Micromus timidus, Hagen.
Aleurodidae.—		
Species not known	,,	
Acridiidae.—		
Zonocerus variegatus L. ...	,,	
Phymateus karschi, Bol. ...	,,	
Diptera.		
Agromyzidae.—		
Agromyza sp	,,	
(G) ATTACKING THE FLOWERS.		
Thysanoptera.—		
Physothrips sjöstedti, Trybon	,,	

Parasites from Aphid Predators.

From—Paragus.	*Chalcidae.*	Sphegigaster sp.
		Paracarotomus cephalotes, Ashm.
	Cynipidae.	Coelonychia spinosipes, Kieffer.
		Aspicera sp.

APPENDIX No. II.

SUGGESTIONS FOR A SIMPLIFIED METHOD OF ANALYSING INHIBITING FACTORS.

Further surveys of the factors inhibiting the development of Ishan cotton will probably be necessary as no complete analysis has yet been made on the improved strains of that variety, and, in addition, valuable information would be acquired in the event of there being an exceptionally bad season comparable to that of 1922-23 when no crop at all was obtained from several of the plots on Moor Plantation. From the information obtained in various surveys the writers have devised a simplified method of carrying out surveys of this nature.

A.—Area and Arrangement of Plots.

Select two sub-plots of one-twentieth of an acre each in a plot of cotton at least five acres in area, the sub-plots being as widely separated as possible and more than fifteen yards from the periphery of the main plot. Stainer index picking has indicated that cotton plots of one acre or less are not as heavily infested by stainers as are larger areas.

B.—Bud Shedding.

It has been shown above that about thirty *per cent.* of the buds shed were not found although collections were made daily. There is little hope of obtaining accurate quantitative figures by any method other than the extremely laborious system of scar-counting. Once a week the two one-twentieth acre sub-plots should be cleared of sheds at, say, 9 a.m. on Wednesday and twenty-four hours later all bud sheds should be collected and analysed. This method, although unsatisfactory from a quantitative point of view, would yield sufficient data to enable an estimation to be made of the relative importance of the causative factors if bud shedding were excessive.

C.—Flower Counting.

A statistical examination was made of the accuracy obtained by counting flowers on one day a week and multiplying by seven to obtain the weekly flowering; in the case of Ishan, Allen and Meko cottons it was found that this method yields sufficiently accurate results.

D.—Boll Shedding.

It was found that to obtain sufficiently accurate weekly boll-shedding figures for Ishan and Meko it was necessary to collect sheds three times a week on alternate days, while for Allen twice a week is sufficient, provided there is an interval of at least two days between the collections. For analytical purposes a sample of one hundred sheds should be examined once a fortnight.

The accuracy of these simplified methods is, of course, largely dependent on the care used in denuding the sub-plots of sheds exactly twenty-four hours prior to the shed collections.

E.—Harvested Bolls.

Picking should be carried out fortnightly, the entire bolls being removed by severing the pedicel. At each harvesting the bolls should then be divided into the following groups:—good, slightly damaged, much damaged and useless. Detailed examinations of the locks from samples of fifty bolls from each group should be made, and the loss of crop due to each inhibiting factor calculated.

F.—Insect Incidence.

(1) The stainer gauge should be carried out in the usual manner.

(2) Bollworm gauges involve very considerable labour, and adequate information as to the incidence of the various species could be obtained from an examination of the larvae found in shed buds and bolls once a fortnight.

ON THE INCIDENCE OF LEAF CURL OF COTTON IN SOUTHERN NIGERIA.

By

C. J. Lewin, B.Sc.

Leaf curl of cotton was first reported in Southern Nigeria by Farquharson in 1912 (1), Jones and Mason (2), in 1926, gave a detailed account of the symptoms of the disease and noted that it was of wide spread occurrence, being especially prevalent on the indigenous species *G. Peruvianum* and *G. vitifolium*. These authors concluded "*The infectious nature of the disease is indicated by budding, and as no organism has been found associated with the disease, it seems that the leaf curl of cotton must be classed with virus diseases. The abnormal internal anatomy, moreover, has a striking resemblance to those abnormalities encountered in other virus diseases.*" It was also stated that when sown in May, during the early rains, almost all plants become infected within a period of four months. July sown cotton is not nearly so susceptible. The abundance of Jassids during the early rains suggested that these insects might be vectors of the disease but negative results were obtained from cage experiments. The present paper records certain observations made during the seasons 1925-26 and 1926-27.

The General Effect on the Crop.

No attempt has yet been made to assess the loss of crop caused by this disease. To do so would be a difficult matter, for the extent of the damage depends largely on the stage in the life history of the plant at which infection occurs. Moreover it appears that, even among plants of the same age which exhibit the first symptoms simultaneously, the effect of the disease varies in intensity between wide limits. Infection occurs, or rather the symptoms are first manifested, at the extremities of the main axis or of vegetative branches. If the plant is infected when very young (*i.e.*, when about one foot in height) it becomes stunted, bears no crop and may even die. Later infections are not so serious and a reduced crop is usually borne. Infections late in the season do not cause appreciable damage. A preliminary investigation of the boll characters of the infected plants was made in December, 1925. One hundred badly curled and one hundred healthy plants were selected from a quarter acre plot of Ishan cotton. From each plant the seed cotton from one ripe undamaged boll was harvested. The weights of seed cotton per boll were determined separately on each boll. The number of seeds per boll and also seed weight (weight of 100 seeds) was also calculated. The results with their probable errors are summarised in Table I.

TABLE No. I.

Character.	Healthy Plants.	Curled Plants.	Difference.
Mean weight seed cotton per boll in grams	3·18± ·042	2·54 ± ·048	·64 ± ·064
Mean number of seeds per boll	20·7 ± ·25	17·6 ± ·27	3·1 ± ·37
Mean seed weight in decigrams	106·5 ± 1·01	99·5 ± 1·15	7·0 ± 1·53

The differences in weight of seed cotton per boll and in number of seeds per boll between the curled and healthy groups are statistically significant. Seed weight was inevitably calculated from an average of about twenty seeds from each individual and this may account for the doubtful significance of the result in this later case. The reduction in the number of seeds per boll is interesting as it indicates the possibility that the disease may inhibit fertilisation to some extent Flowers of badly curled plants are reduced in size and both the epicalyx and corolla show the lesions characteristic of the disease. No significant difference was found to exist between the curled and healthy plants in respect of the mean maximum lint length or of ginning percentage. It was not possible, at the time, to compare other measurable lint characters.

The Incidence of the Disease.

The mapping of certain badly infected areas showed that the incidence of the disease is usually most severe at the edges of cotton plots, and that diseased plants frequently act as foci of infection. Usually the disease appears to spread inwards from one or more borders of a plot, but frequently there are local areas within the plot in which infection has spread from one more or less centrally situated plant. These facts are additional evidence in favour of an insect vector of the disease. The general course of the spread of the disease is as follows:—In July sown cotton, the disease first appears in the middle of August and spreads with varying rapidity until November when the rains normally cease. Then follows a long period during which no further manifestation occurs, in fact field counts usually show a decrease from November onward. This apparent decrease is due partly to defoliation and partly to the fact that, on slightly affected plants, the symptoms are not easy to distinguish in the dry season, when the leaves are wilted for the greater part of the day. No case of true recovery from the disease has been observed. Following almost complete defoliation in January, the early showers, which usually occur in the latter part of January or

the beginning of February, cause rapid growth of new shoots. The disease, which during the dry season had been unable to manifest i self, now spreads rapidly and by the beginning of April almost all stands are affected. This end of season susceptibility has little effect on the crop, the bulk of which is ripe by the end of January Typical infection curves for the whole season are shown in the upper figure Until the vector is isolated and the period of incubation of the disease is known, it cannot definitely be stated that infection does not occur during the dry season, for the rapid spread of the disease at the beginning of the rains may be merely the manifestation on new shoots, of previous infection. It seems more probable, however, that the climatic conditions which obtain during early rains favour both inoculation and manifestation of the disease. With the object of obtaining some idea as to the incidence of leaf curl on various types of cotton, weekly counts of the number of plants showing symptoms of the disease were instituted, in 1925, on certain quarter acre plots situated in the same ten acre block on Moor Plantation, and simultaneously on similar plots near the Adio road about five miles to the west. The Adio block was surrounded by thick bush. The results, which are summarised in Table No. II, are expressed as the mean percentage infection on five plots in the case of Allen cotton, and on two plots in the case of Meko (*G. Peruvianum*) and of Ishan (*G. vitifolium*). The approximate number of plants per plot is given at the head of each column.

TABLE No. II.

The Incidence of Leaf Curl on three types of Cotton.

	Block A6 Moor Plantation.			Adio Road Block.		
Date (week ending).	Allen 1,500.	Meko 950.	Ishan 950.	Allen 1,500.	Meko 850.	Ishan 850.
September 19th	1	*	*	0·5	*	*
„ 26th	1	*	*	0·5	*	*
October 3rd	1	*	*	0·5	6	8
„ 10th	1	4	7	1	7	9
„ 17th	1	5	8	1	8	10
„ 24th	1	5	8	1	10	12
„ 31st	1	5	8	1	11	17
November 7th	1	7	8	1	12	19
„ 14th	1	7	10	1	*	*
„ 21st	1	7	11	1	14	20
„ 28th	1	7	9	1	13	21

* Signifies no census.

It is clear that Allen is not nearly as susceptible as the indigenous types, and that of these, Ishan appears to be less resistant than Meko. On none of the plots from which these figures were obtained was the disease exceptionally severe, but counts made in October, 1925 on other plots on Moor Plantation gave infection figures as high as thirty *per cent.* on a plot of Meko and sixty *per cent.* on a plot of Ishan cotton. There can be little doubt that the disease may cause an appreciable loss of crop, and it is also possible that the quality of the lint may be affected. This latter point will be investigated at an early date.

Resistance to Leaf Curl.

That some individuals, both of the Meko and Ishan types, possessed a degree of resistance to the disease, was evident from the field observations. Healthy individuals surrounded by badly infected plants were found so frequently that the apparent immunity of these plants could hardly be considered accidental. Moreover in 1925 two strains of Ishan cotton (3) in a selection plot exhibited a far higher degree of resistance than did the remainder. In this plot progeny rows of the various strains were arranged in the following order :—

G, Meko : A, B, C, D, E, F, G, Meko : A, B, etc.

The rows were six feet apart and each contained seven plants spaced at a distance of five feet. There were eleven replications of each strain. The Ishan strains A, B, C, etc., were the offspring of self-fertilised individuals of the 1924-25 crop. These individuals were in turn offspring of the original selections made from native farms in 1924. A and B were sister strains derived from two individuals of the progeny of one of the original selections. C and D and also F and G were similarly related. The Meko rows were established from seed obtained from the Ibadan ginnery. The incidence of the disease in each strain is summarised in Table III. Diseased plants were uprooted immediately the symptoms appeared until November, when all stands, whether diseased or not, were left.

TABLE III.

PERCENTAGES OF STRAINS AFFECTED BY LEAF CURL AT VARIOUS DATES.

Selection Plot 1925–26.

Date.	A.	B.	C.	D.	E.	F.	G.	Meko.
August 31st	—	1	—	--	2	—	—	—
September 15th	—	1	—	1	4	3	—	—
„ 30th	—	1	2	1	5	3	—	—
October 15th	—	1	2	1	7	5	—	—
„ 31st	—	3	10	1	20	10	3	—
November 15th	—	4	15	3	25	13	5	2
„ 30th	—	4	27	9	39	22	8	5
December 15th	—	4	32	10	40	23	11	10
Dec. 31st—Feb. 15th ...	No Further Increase.							
February 28th	4	9	63	36	70	72	65	35
March 15th	4	18	82	53	85	86	83	60
„ 31st	47	74	100	90	99	93	93	91

The figures indicate that varying degrees of resistance obtained in the population and that Strain A was for all practical purposes immune, since no plants were affected until new shoots appeared in February. Owing, however, to the small number of plants, the wide spacing, and the fact that Strain A in particular was favoured by its situation between rows of comparatively resistant plants (*i.e.*, those of B and Meko) the result obtained, while suggestive, could hardly be regarded as conclusive. In the following year (1926-27) further evidence was sought as to the resistance of Ishan strains. At the conclusion of the 1925-26 season, strains C, F and G, for various reasons were discarded as unsatisfactory, but in 1926-27 selfed seed from selected plants of A, B, D and E, was sown in a selection plot, while the remaining seed of each strain was bulked for multiplication. The spacing of the selection plot was similar to that of the former one, but there were fifteen plants to a row and ten rows of each strain. The arrangement was A, B, D, E, A, B, etc. The multiplication plots were situated as follows:—

Strain A.—$4\frac{1}{2}$ acres in blocks E5 and E6 Moor Plantation.
,, B.—8 acres in the Adio road block.
,, D.—5 acres in blocks Y.O. & Z.O., Moor Plantation.
,, E.—$1\frac{7}{8}$ acres in blocks B.1. & C.6., Moor Plantation.

On these plots the spacing was wide, being $6' \times 4'$, with exception of strain E which was spaced $6' \times 2'$. Counts of infected plants were made weekly on the selection and multiplication plots and the results are summarised in Tables IV. and V.

TABLE NO. IV.

Percentage of Plants affected by Leaf Curl at various dates.

Selection Plot 1926–27.

Week ending.	A.	B.	D.	E.
August 14th	1	—	1	1
„ 21st	3	1	1	2
„ 28th	3	1	3	4
September 4th	3	2	7	7
„ 11th	3	2	7	7
„ 18th	3	2	9	11
„ 25th	3	2	12	15
October 2nd	4	2	13	20
„ 9th	4	3	18	23
„ 16th	4	3	21	27
„ 23rd	5	4	23	29
„ 30th	5	5	25	31
November 6th	5	5	25	34
„ 13th	5	6	27	35
„ 20th	5	6	29	41
„ 27th	5	6	30	43

TABLE NO. V.

Percentage of Plants affected by Leaf Curl at various dates.

Multiplication Plots 1926–27.

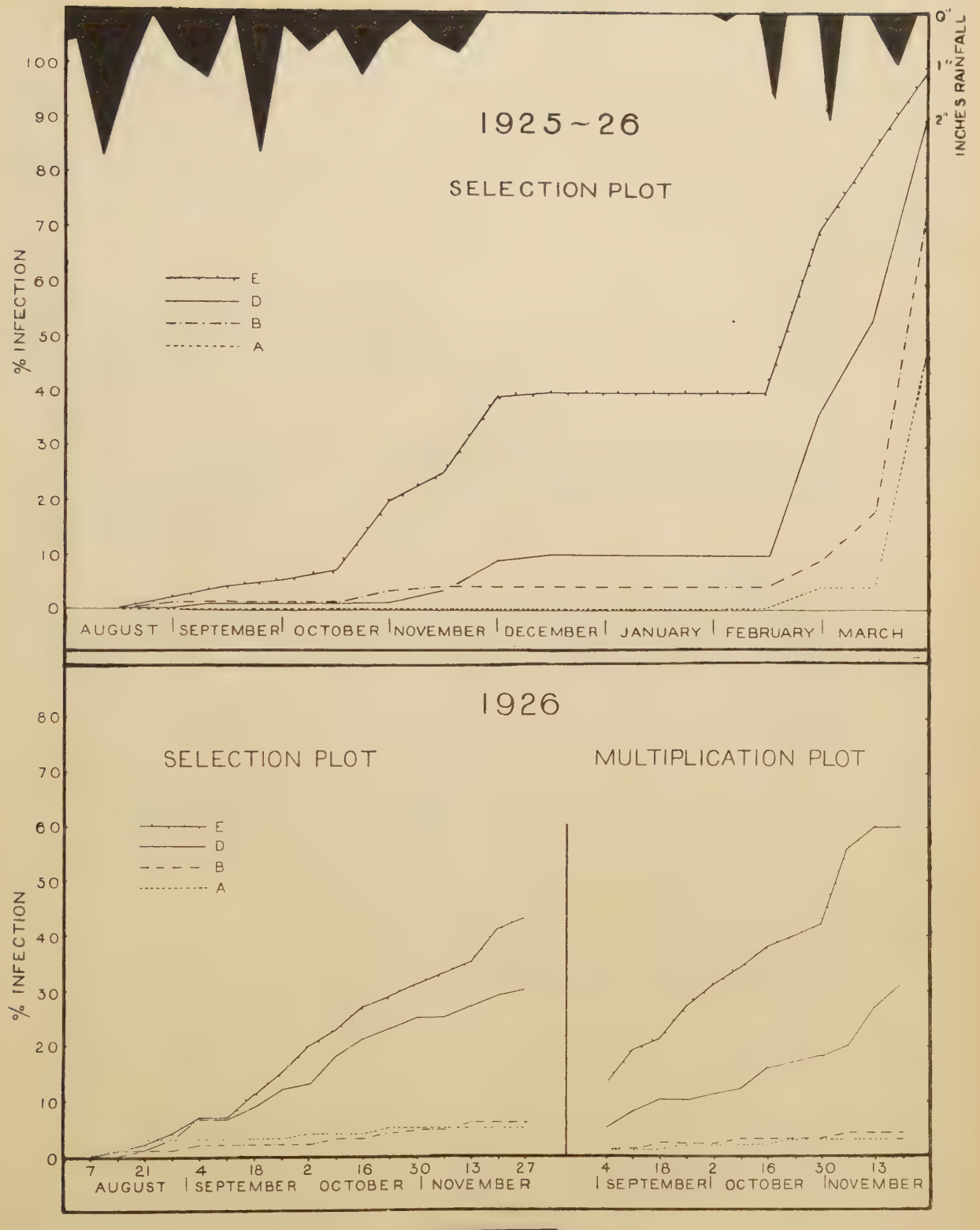
Week ending.	A 8,000 plants.	B 15,000 plants.	D 10,000 plants.	E 7,000 plants.
September 4th	1	1	6	13
„ 11th	1	1	8	19
„ 18th	1	2	10	21
„ 25th	2	2	10	27
October 2nd	2	2	11	31
„ 9th	2	3	12	34
„ 16th	2	3	16	38
„ 23rd	3	3	17	40
„ 30th	3	3	18	42
November 6th	3	4	20	56
„ 13th	3	4	27	60
„ 20th	3	4	31	60

It will be seen from these tables and from the figure that the incidence of the disease was remarkably constant for each strain during two seasons and in three series of observations. Figures for the latter part of the 1926-27 season are not available, but casual observation indicated that the trend of the disease was substantially the same as that observed in the selection plot in 1925-26 and that recorded by Jones and Mason. It may be concluded, therefore, that strains A and B are highly resistant, and that the resistance to leaf curl is hereditary. The similarity between the sister strains A and B is of interest, for it obtains not only for the leaf curl resistance but for habit, lint characters, size of boll, and ginning percentage.

It seems probable that resistance to leaf curl in cotton is correlated with some morphological character. Pubescence immediately suggests itself for it seems likely that the vector is some small insect whose activities might well be checked by the presence of hairs on the plant. The high degree of resistance possessed by Allen cotton (*G. hirsutum*) may possibly be due to this character. In the year 1925-26 season a census of hairy plants was taken on the selection plot. The method adopted was an arbitrary one, namely the feeling of several leaves on each plant by assistants working independently of each other. The results obtained showed that all individuals of strains C, D, E, F and G and also those of Meko cotton fell below the arbitrary standard of hairyness, while strain A was classed as 100 *per cent.* and strain B as thirty *per cent.* hairy. In season 1926-27 a similar census on the selection plot failed to confirm the result of the previous one, for no difference in hairyness between the strains could be detected. Moreover, it appears probable that infection occurs near the apical buds of branches, and the unopened leaves in these regions are invariably hirsute. Pending further and more critical investigation, therefore, no definite statement on the correlation of resistance with pubescence can be made. Strains A and B were also of later maturity than the more susceptible remainder, but it seems hardly likely that this character can be connected with the disease, the symptoms of which may appear when the plant has barely passed the seedling stage.

An Immunity Test.

It has been stated that the indigenous cottons are highly susceptible to leaf curl during the early rains but that this susceptibility diminishes as the normal time of planting (*i.e.*, the beginning of July) approaches. It was thought that this period of high susceptibility might be utilised in the isolation of a totally immune strain of cotton. Accordingly, in April, 1926, seeds from self fertilised bolls of plants which had remained healthy in the selection plot until the end of March, were planted in rows alternating with similar seed from plants known to be highly susceptible.



Showing the incidence of Leaf Curl on four strains of Ishan Cotton.

Some slight initial degree of resistance was noticed on certain plants but by the end of June all stands showed lesions of the disease. Thus no evidence of absolute immunity could be obtained. The complete resistance to the disease by certain plants during the period from July to March was evidently overcome by the environmental factors which favour infection in April, May, and June.

Summary.

1. Figures of the incidence of the disease of leaf curl on various types of cotton have been given. It is suggested that Ishan cotton (*G. vitifolium*) is slightly more susceptible than Meko (*G. Peruvianum*).

2. A preliminary investigation has shown that the disease causes a reduction in the size of bolls due to a reduction of the number of seeds per boll. The possibility that fertilisation may be inhibited to some extent is suggested.

3. Evidence that resistance to this disease is hereditary has been adduced, though no crossing experiments have yet been attempted. Two highly resistant strains of Ishan cotton have been isolated.

4. Even highly resistant cottons appear to become susceptible to the disease during the early rains. No case of absolute immunity has yet been observed.

The author is indebted to Mr. E. H. G. Smith for the census of diseased plants during the 1926-27 season.

Literature Cited.

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NOTES ON A VISIT TO THE OIL PALM PLANTATIONS OF SUMATRA AND MALAYA IN 1926.

BY

H. B. WATERS, B.A.

INTRODUCTION.

The chief object of my visit to the East Indies was to study the oil palm plantation industry on behalf of the Nigerian Government. I spent the months of August and September, 1926, in Sumatra and Java, in company with Mr. G. G. Auchinleck, Deputy Director of Agriculture, Gold Coast, and then visited Malaya during October. Some idea of the extent of the tour may be gathered from the fact that the area of oil palm estates visited was 60,000 acres out of a total of 75,000 planted by the end of 1925, so that we had opportunities of observing oil palms growing under many different sets of conditions and we were able to visit factories representative of every type. In this paper I have not attempted to give a complete account of the palm oil industry of the East, but rather to record recent developments and new features of interest. I have tried to include those facts and discussions which in my opinion are likely to be of value as a contribution to the study of the oil palm industry, and for the purpose of formulating a progressive policy with regard to palm oil in Nigeria.

AREAS AND POPULATION.

Some idea of the relative size of the various countries visited will be useful (4) *(5) : in the table below this information is given together with similar figures for Nigeria and the Gold Coast.

	Area in sq. miles.	Population.	Population per square mile.
Java	50,752	34,984,712	689
Sumatra	163,145	5,852,135	36
British Malaya	56,602	3,358,054	59
Nigeria	367,928	19,000,000	52
Gold Coast...	91,690	2,300,000	25

Java, it will be noticed, is very heavily populated, it is the country from which labour is obtained for the rest of the Netherlands

* Figures in brackets refer to the list of references given on page 120 at the end of this report.

East Indies. Coolies for Sumatra and the other Islands are recruited from Java on a system of indenture. The coolies in Malaya, however, are mostly Tamils from Southern India. Sumatra, it will be seen, is nearly half the size of Nigeria, and has a population of nearly six millions; it has a population of thirty-six persons per square mile compared with fifty-two in Nigeria.

Trade.

The average annual trade (4) (5) for the five years 1920-24 gives a good idea of the wealth of these prosperous colonies.

	Total trade : Imports plus Exports.
	£
Java (with Madoera)	123,200,000
Outer Islands (including Sumatra)	70,600,000
British Malaya (1925 only)	268,500,000
Nigeria	25,400,000
Gold Coast	17,400,000

Java can now be considered to have been completely opened up, for this beautiful island is now very well supplied with railways, roads and first-class buildings, and the population is as high as it can be with comfort. Every available piece of land is utilised in some way by European-managed estates or by Javanese farmers; it is an amazing fact that twenty-three *per cent.* of the land in Java, *i.e.*, 12,000 square miles, is irrigated, usually in terraced slopes, for the cultivation of paddy. The Dutch now appear to be concentrating on Sumatra in the matter of " opening up " their backward colonies. Sumatra is openly considered by them to be the " Island of the Future." Judging from the way in which the towns, roads and railways in Sumatra are being laid out, there appears to be every prospect that it will be an increasingly prosperous and pleasant country to live in. At present most of the European estates are concentrated round Medan in Sumatra's East-coast, while there are a few estates in the vicinity of Padang and of Palembang.

GENERAL DESCRIPTION OF ESTATES.

History of the Oil Palm Industry.

The history of the introduction of the oil palm from Africa into the Netherlands East Indies is contained in an authoritative publication (1) issued in Sumatra in 1922. According to this Bulletin, four oil palms were imported in 1848, and for many years

their progeny was widely distributed and planted as ornamental trees in the gardens of Europeans and as avenues on estates. In addition, a number of experimental plots were planted in various localities in the middle of 19th century, but this did not result in trials on a commercial basis. The oil palm was used solely for ornamental purposes until 1910, when a Belgian company, under the direction of M. Hallet, established the first oil palm plantations. M. Hallet, who had had experience in tropical West Africa, observed how exceedingly well the oil palm grew in Sumatra as compared with the palms he had seen in Africa, and decided that plantations of oil palms were well worth a trial. The first plantations were sufficiently successful to interest more planting companies in the crop, with the result that the acreage under oil palms has increased with great rapidity. At the end of the Great War about 12,000 acres had been established, but by the end of 1925 more than 60,000 acres had been planted up in Sumatra.

Area Planted.

The rate of development can be gauged from the following table:—

Year.	Sumatra.	Java.	Malaya.	Total.
1915	6,500	—	10	6,510
1920	22,400	—	1,125	23,525
1925	60,350	1,406	9,694	71,450

(Note that the area, planted by Handelsvereeniging "Amsterdam," is not included in the table above: this area is estimated at 8,000 acres in 1925, but may be greater).

Full figures are given in Table No. 1, which shows that a yearly increase of twenty-four *per cent.* on the previous year's acreage has been maintained for the period 1921-25. Sixty-three *per cent.* of the total area established by the end of 1925 had been planted in the third and most recent five-yearly period, *viz.*, 1921-25, and twenty-three *per cent.* of the total area planted by the end of 1925 was planted in the year 1925. As the oil palm comes into bearing on the average in the fifth year and into full bearing in the tenth year, the acreage of bearing palms in Sumatra at the end of 1926 was about 30,600, of which 8,500 were in full bearing and 6,350 were in their first year's bearing. It is necessary to stress this point in order to show why the export of oil from Sumatra in 1926 was only 11,000 tons, when statistics show that more than 60,000 acres had been planted up by the end of 1925; the reason, of course, is that only a small proportion of these 60,000 acres are as yet in full bearing.

A number of estates were engaged in clearing and planting programmes during 1926, and the new areas of five of the estates visited were stated by the managers to amount to 6,605 acres. In 1926, concessions on the West Coast of Sumatra amounting to 200,000 acreas were obtained by two of the largest companies with a view to planting oil palms there. Another company intends to plant up 50,000 acres by the end of 1930, it is understood, if their plantation which is now coming into full bearing, is a success. It appears therefore that the establishment of plantations is likely to proceed even more rapidly than before, and that within a decade the Dutch will be in a position to supply a large quantity of palm oil equivalent to the present yearly output of the West Coast of Africa.

Location of Estates.

All the Sumatra estates are at present situated in the North-east coastal belt in the vicinity of Medan, with the exception of a few acres near Palembang; but the West Coast, north of Padang and west of the mountain range, may become a palm oil country in the future. In Malaya, the area of oil palms is much smaller than in Sumatra, but, as the palm grows well there and planters are taking an increasing interest in the crop, a regular increase in the acreage is expected. Most of the present estates are near Kuala Lumpur. In Java, no increase is likely to take place, for in East Java the dry climate is unsuitable, and even in West Java the palm does not thrive as well as in Sumatra; nor is there room in Java for new extensive cultivations.

Relation to Other Perennial Crops in Sumatra.

Figures showing the acreages planted in various crops in Sumatra are given in a yearly publication by A.V.R.O.S. (6).

	1924.		1925.		Increase.	
	Acres.	Per cent. to total area.	Acres.	Per cent. to total area.	Acres.	Per cent.
Hevea	430,000	79	476,000	79	+46,000	+11 %
Oil Palms	46,800	8½	60,350	10	+13,550	+29 %
Tea, Coconuts, Coffee, Gambier, etc. ...	67,400	12½	65,800	11		
	544,200	100	602,150	100		

This table clearly indicates the growing importance of the oil palm area. Hevea still remains by far the most important crop, comprising nearly half a million acres. Oil palms are second in importance and are increasing relatively at a greater rate. Tea comes next with 10,000 acres, or four *per cent.* of the total area under plantation crops at the end of 1925. Nearly 60,000 acres of new land was planted in hevea and oil palms during the year 1925; this indicates the rate at which the oil palm area could expand if for any reason the further expansion of hevea were thought undesirable and development were confined to oil palms, though of course at present hevea still offers attractive possibilities and its development is likely to continue.

Planting Firms.

The most important firms, judged on an acreage basis, in the oil palm industry in Sumatra are given below :—

	Area planted at the end of 1925.
Société Financière des Caoutchoucs	29,250 acres
Rubber Cultuur Maatschappij "Amsterdam" ...	13,100 „
Handelsvereeniging "Amsterdam"	(not available)
Marihat Sumatra Plantagen Co.	5,250 acres
Société Internationale de Plantations et de Finance	3,010 „
Various (8 companies)	9,750 „
Total	60,350 acres

Some of these companies act as agents for other companies, and the latter have been included with their agents in the table above. Actually there are twenty-three companies engaged in the industry. The acreages planted by each company are to be found in " Statistiek " (6), published by A.V.R.O.S., and their addresses in " Adresboek," published in Medan.

Production and Export.

Various figures for production and export for previous years have been published, but unfortunately they do not always agree. For 1924, an official publication (8) gives the total export as 5,200 metric tons of pericarp oil, valued at 2,185,000 guilders (£182,083), which is equivalent to £35 a metric ton. A.V.R.O.S. " Statistiek " (6) states that the production for 1925 was 6,000 tons of pericarp oil and 1,200 tons of kernels, excluding the production of Handelsvereeniging " Amsterdam " and of the Marihat estates. In comparing export figures with production figures it should be remembered that an increasing quantity of oil is manufactured locally each year into soap.

PRODUCTION OF PALM PRODUCTS IN THE NETHERLANDS EAST INDIES.

Year.	Palm oil.	Kernels.	Fruit.
	Metric tons.	Metric tons.	Metric tons.
1920	1,506	338	—
1921	2,149	153	—
1922	3,821	512	—
1923	3,874	727	246
1924	5,200	1,391	—
1925	7,612	1,267	—
1926	11,023	1,580	—

(NOTE :—Figures from various sources).

An interesting feature of the export is the fact that Holland was the leading market until 1923, England became the leading market in 1924, and America in 1925. A small quantity was exported to Australia for the first time in 1926.

THE PLANTATIONS.

ENVIRONMENTAL CONDITIONS.

Thirty-three plantations large and small, have been established in separate areas on the East Coast of Sumatra. These areas differ as regards soil, aspect, height above sea level, rainfall and climate. It is evident therefore that the Dutch planters have had ample opportunity of discovering the environmental conditions most suited to the oil palm, and actually they have obtained a great deal of information on this subject. Some of the original plantations were established in places that would not now be considered suitable, and some of the best places have not yet been planted up Any attempt, however, to guage the relative importance of the various factors affecting yield cannot be considered final, and the following remarks can only be regarded as my own personal opinion as the result of observation in Sumatra.

Amongst the soils observed were light loams with shale subsoil, black peat over clay, deep loams, laterite, and sandy soils. The best results so far have been obtained from deep loams with a high content of humus. It is recognised that oil palms require a richer soil than that required by hevea or by coconuts. Provided, however, that the soil is fertile, it does not appear that the *type* of soil is a matter of prime importance, for palms were observed to be thriving

on soils of every description. Analyses of soils are given in a publication by Dr. T. T. B. Deuss (13).

As far as aspect is concerned, palms were observed to be growing well on hilly, on undulating, and on flat land; but its character in this respect does not appear to be important from the point of view of growth and yield. On hilly land conservation of fertility is a matter of importance, and on flat land suitable drainage is usually essential. In general, however, fairly flat land is usually more fertile and therefore more productive.

The oil palm thrives in Sumatra at sea level and at 1,200 feet above sea level, so that within these limits height above sea level is an unimportant point. The palms growing at 1,200 feet looked at least as robust and vigorous as those growing at lower elevations, and judging from their appearance they were yielding equally abundantly.

The rainfall (11) of the oil palm district varies from eighty to 180 inches per year. The rain is well distributed throughout the year; long periods of drought, similar to those which occur yearly in Java and in Nigeria, are unknown, and the rainfall of the driest month does not as a rule fall below four inches. There is usually a double yearly period of rainfall as in the oil palm belt of Southern Nigeria; the rainiest season occurs in October and November, and the secondary maximum falls in April and May. Throughout the year the morning hours are the driest, and most rain falls during the afternoon and evening hours; the minimum rainfall occurs between 10 and 11 a.m. and the maximum at 6 to 7 p.m. on the average. Days of sushine are frequent (12) and the temperature is comparatively equable throughout the day and throughout the year.

Now that the environmental conditions in Sumatra have been briefly studied, we are in a position to discuss why the Sumatra oil palms grow so amazingly well and give such high yields as compared with Nigerian oil palms. But first I must hasten to add that my knowledge of Nigerian oil palms is limited to the belt west of the River Niger, for I am assured that east of the delta the conditions are much better and that the oil palms grow much more luxuriantly there. Of the factors already mentioned, aspect and height above sea level have been eliminated as factors not having any great effect on the yield. Four factors now remain, *viz.*, soil, cultivation, climate and variety. I believe that Nigerian soils are at least as fertile as Sumatra soils, and I have already stated that the *type* of soil is not a matter of great importance. Hence although it is just possible that the soil in Sumatra is, by some hidden virtue, peculiarly suited to the oil palm, I think that it is extremely unlikely. Efficient cultivation

naturally leads to better yields, but it does not account for the size and robustness of trees growing as ornamental palms or of those trees in Sumatra which have not been well cultivated. By the process of elimination therefore we are reduced to the two remaining factors, climate and variety. The effect of the climate is that the palm makes progress throughout the year, for it is not subjected to that trying period of drought and extremes of temperature known in Nigeria as the Harmattan. The result of a heavy rainfall, equable temperature, and frequent sunshine is that the palms come into bearing earlier and manufacture oil throughout the year. The superiority of the variety of oil palm in Sumatra will be discussed later: at present I will only bring forward the negative argument that recent importations from West Africa have given such poor results that it has been thought advisable to destroy them, and that the Dutch have been unable to find a new superior variety to replace their present one. It seems to me that the Sumatra climate and the Sumatra variety are together responsible for the rapid growth and prolific qualities of its oil palms, but how far the climate is answerable and how far the variety, is a matter for conjecture.

The "Deli" Type Oil Palm and its Selection.

The Dutch planters were extremely fortunate in that the type of palms introduced originally was of exceptionally good standard. It is known as the "deli" type and is still the only variety of commercial importance in the East. Its main characteristics are a high content of oil to fruit, early maturity, robustness, large size of bunch, and high productivity. None of the later introductions has given promising results; those estates which had planted out considerable areas with "Congo" type seed soon decided to cut them out because of the poor yields obtained.

A bunch of a "deli" palm is distinctive, for when it is nearly ripe it resembles a magnified blackberry in appearance. A fruit can be easily recognised by cutting it across with a sharp cutlass, when the cross section has a target-like appearance, as the thickness of the pericarp is practically equal to that of the shell and the diameter of the kernel is about equal of that of the pericarp and shell together. Compared with the common "thick-shelled" fruit of Nigeria, the pericarp is much thicker, the shell is slightly thinner and the kernel is very slightly smaller. It will be interesting to see how the "deli" type does in Nigeria. Seed obtained from Sumatra in previous years failed to germinate, but two lots of seed (one from Monsieur M. Ferrand, Scientific Adviser to the Société Financière des Caoutchoucs, and the other from Dr. A. W. K. de Jong, Director of the General Experimental Station, A.V.R.O.S.) were planted out in

germination beds early in 1927 at Moor Plantation, Ibadan, and are growing well. The average compositions of the " deli " and the Nigerian " thick-shell " type are given below :—

	Sumatran fruit.	Nigerian hard shell.
	%	%
Pericarp Palm oil	31	21
Fibre and moisture	29	19
Nut Shell	32	48
Kernel	8	12
	100	100

Compared with Nigerian palms, the general standard of the deli palms is high, and the variation from palm to palm is not so great; but the deli palms are by no means uniform. The fruits of individual trees differ in size, shape and thickness of shell, while the palms themselves vary in habit and rate of growth, and produce bunches of varying sizes. Some of these variations are strikingly evident when walking through a plantation for the first time as for example; high trees and short trees, big and slender girths, upright and drooping leaves, and large and small bunches; more thorough examination brings to light further variations, such as bunches with long spines or with short spines, fruits with thick pericarp and with thin, and fruits with thick shell and with thin; while detailed investigation over a number of months reveals additional variations, amongst which may be mentioned the yield, for while some trees give a yearly yield of four hundredweight of fruits, others give comparatively low yields, and a few trees fail to yield any fruits at all.

The Dutch planters, observing these variations, soon realised that maximum productivity per acre could not possibly be approached until every tree in the plantation was a good one, and further that breeding and selection work held out distinct possibilities, with the result that the work of selection has now been progressing for several years. At present the A.V.R.O.S. Experimental Station is carrying out selection work with the object of producing a superior type with a thinner shell and a thicker pericarp than the average deli type. Botanical officers, in the service of the larger companies, spend a large part of their time breeding new strains and propagating superior types. As an example, it was observed that all the new clearings, which are being opened on the estates of the Société Financière des Caoutchoucs, were being planted up with seedlings that had been selected and grown by M. Ferrand, who is their Scientific Adviser. His work was extremely interesting and merits some attention here.

By continued observation of the oil palm for some time, Mr. Ferrand is now able to gauge the yielding qualities of any particular tree with a fair degree of accuracy by external characteristics. He has found that a high yield is correlated to a large extent with the following factors :—

(*a*) slow vertical growth in the trunk;
(*b*) girth above average in thickness;
(*c*) leaves long and heavy, and drooping towards their outer extremities; broad strong leaf bases with wide leaf axils, providing ample room for bunches;
(*d*) bunches of large size.

The first factor (*a*) is of special importance, for while M. Ferrand asserts that the slow grower yields the best, it is the quick growing palm that has the best chance of survival in the Nigerian palm grove, where natural selection throughout the centuries may have resulted in a preponderance of fast growing trees at the expense of heavy yielding trees. Thickness of girth (*b*) has been shown to be correlated with yield on the wild palms at Moor Plantation, Ibadan. The next desirable character (*c*) refers mainly to the shape of the palm; viewed from the side, the semi-circular head of the green leaves of a good tree has a reflex angle, *i.e.*, greater than 180 degrees, and that of a bad tree has an obtuse or acute angle, *i.e.*, less than 180 degrees. The latter is usually though not always associated with a quick growing tree. Finally M. Ferrand's contention (*d*) that large bunches indicate a big yield is interesting, for the total yield of oil and kernels is the decisive factor and within limits it does not matter whether this yield is obtained by a large number of small bunches or by a small number of large bunches; but in his records on numerous trees he has found that those trees which give large bunches in one season give large bunches in the next and that some trees invariably give small bunches, and that the yield of the former is usually appreciably greater than that of the latter. It is not suggested that the characteristics mentioned are an infallible guide to the yielding qualities of any particular tree, but that they give a very good indication; if a hundred best trees and a hundred worst trees were selected according to these external qualities, there is no doubt that the average yield of the former would be much higher than that of the latter.

Having selected a number of trees by observation of the harvest and external qualities, the yields of these palms are recorded separately. For each bunch is recorded the total weight, the weight of fruit, and the weight of depericarped nuts. The weight of pericarp is recorded by difference; and the percentage weight of fruit to bunch, and pericarp to fruit, are calculated. In Table No. 2 the yield record of the best all round individual palm, both from the

point of view of yield and of external characteristics, on the estates of the Société Financière des Caoutchoucs is given; the yields are for thirty-six weeks, and give the following totals:—

	Weight lbs.	Weight contained in average bunch lbs.
11 Bunches	723	66
Fruits	411	37
Nuts...	106	10
Pulp	305	27
Pericarp oil	168	15

Percentage weight fruit to bunch 56%
„ „ pericarp to fruit 74%
„ „ nuts to fruit 26%
„ „ oil to pericarp 55% (assumed).

This palm is between eleven and twelve years of age, so that it has been in bearing for about seven years. It is growing in Selele estate and did not appear to be specially favoured as regards environmental conditions. An acre of such palms planted at a distance of $30' \times 30'$ triangular spacing would yield more than four tons of oil! It is not suggested that such a high yield will be reached, as the result of selection alone, but there is very indication that better yields than the present yield of $\frac{1}{2}$ to $\frac{3}{4}$ ton of oil per acre will be obtained when the plantations of selected palms come into full bearing.

The next step in selection work is to carry out cross or self fertilisation with the most promising trees. M. Ferrand uses paper covers for the female inflorescences and is satisfied that this method is trustworthy; his special coolies soon become expert in knowing when each female bunch is ripe, so that canvas bags with glass windows are considered unnecessary. Self-pollination is not usually possible, as male and female bunches rarely mature at the same time, but a number of cases of self-fertilisation have been successful. The method of carrying out breeding work just described may not be the best method that could be devised, but it is certainly giving excellent results. While the breeding work is being confined mainly to the deli variety, the possibility of importing a superior type from Africa or of breeding something useful from African varieties is not being overlooked, and of these *pisifera* and *ayara mbana* are considered to hold out the best prospects.

When it is remembered that the oil palm has been grown commercially in Sumatra for a few years only, the results which have been obtained so far are amazing. In the older plantations the variations in the height of the palms is the most striking feature, while closer inspection reveals the fact that quite a number of the palms give very small yields or nothing at all. The newer plantations form a distinct contrast for not only can acres of palms be seen of uniform height and robustness, but also each tree appears to be

almost a replica of the others as regards size of bunch and quantity of fruit on the palm. These palms are already supplying material from which new and better strains may be chosen.

Every planter is anxious to use improved seed, which can be bought at reasonable prices from various estates. In this connection I wish to record that in my own opinion any person who intended to plant up an area of oil palms in Nigeria would be well advised to use Sumatra seed, which I believe is more likely to give immediate results than locally selected seed. Eventually it ought to be possible to breed a still better type from Nigerian palms, but it will probably take a number of years before success is achieved. This, however, is not the opinion of some officers of the Agricultural Department who have had an opportunity of visiting the Calabar district, where I am assured that the palms are much superior to those near the Western Railway.

Establishing the Young Plant.

Germination.—The germination of the oil palm seed is very slow and uncertain unless some procedure is adopted to accelerate the process. Various methods are employed, and all are based on the application of heat to the seed. Depericarped seeds germinate more quickly than whole fruits, and fresh seeds give better results than seeds which have been stored and allowed to dry. The usual method in Sumatra is to soak the clean seed in water for a week before sowing and to bring the temperature of the water up to 45-50 degrees centigrade three times a day during the soaking period. By this method, a germination of eighty *per cent.*, beginning at three months and complete in six months, is considered satisfactory, compared with thirty to fifty *per cent.* in from nine to twenty-four months for untreated seed. A second method, observed in Malaya, consists of burying the seed in a pit about three feet cube and covering with a layer of fresh dung and sand. The dung generates heat during fermentation and warms the seed. This method is not so clean or efficient, but can be made to give good results if the temperature is carefully controlled. A third method was observed under trial at Serdang Experimental Station, Malaya. Good results were first obtained by planting in a sand bed which was watered daily and left open to the sun's rays but much quicker germination was obtained by covering the sand beds with a grass frame. Mr. Milsum, who initiated these experiments, stated that with the open sand bed he obtained a germination of thirteen *per cent.* at the end of two months and forty *per cent.* at the end of three months, while with a glass covered sand bed he recorded fifty *per cent.* germination at the end of two months, and eighty *per cent.* at the end of three months. It is interesting to record that the open sand bed method occurs naturally in Southern Nigeria, for it is common to observe

thick clusters of seedlings growing on the sand banks in streams during the dry season.

Transplanting.—As each plant in the germination bed becomes of sufficient size, it is transferred to nursery beds at a spacing of about three inches by six inches, and later it is transplanted in the nursery, which is usually part of the clearing where the oil palms are to be planted out, at a spacing of about nine inches by eighteen inches, where it remains until it is ready to be planted out in the field. Each plant therefore is usually twice, and sometimes thrice transplanted. The usual period from time of sowing to time of final transplanting is nine to twelve months, although in several cases plants two or three years of age were observed being transplanted. The oil palms in Sumatra are grown without shade from the seedling to the mature palm.

Spacing.—In Sumatra, nine metres equilateral spacing is considered to be the best system of planting. The original spacing is the final spacing; in other words, subsequent thinning out is not practised. It is important therefore that the palms are originally spaced at such a distance that they will practically cover the land when they are in full bearing. Where conditions are not too favourable, as observed on an estate near Buitenzorg in Java, the palms should be planted closer, and where conditions are excellent wider spacing up to ten metres equilateral is considered advisable. Wider spacing than this is not recommended: on one estate in northern Sumatra the palms were planted at twelve metres triangular spacing and now that it is obvious that the spacing is much too wide it is almost impossible to increase the number of palms without causing over-crowding. In Malaya, thirty feet triangular or twenty-eight feet square is regarded as correct spacing. It is worthy of note that the present spacing is the result of experience, based on a knowledge of coconut cultivation, and that properly laid out experiments do not appear to have been carried out in the East. The possibilities of close planting and subsequent thinning have not been elucidated, nor is it considered feasible. The number of trees per acre for various spacings are :—

	Number of palms per acre.	
	Square spacing.	Triangular spacing.
9 metres (29·5 feet)	50	58
12 „ (39·3 feet)	28	33
28 feet	56	—
30 feet	—	56

Field Methods.

Lalang.—The chief difficulty in cultivating oil palms in Sumatra lies in combating that pernicious perennial grass weed, lalang. Most of the hevea and oil palm estates, both in Sumatra and Malaya, are being planted on virgin soil. After clearing the forest, the land very soon becomes covered with patches of this grass, which if unchecked will cover the whole area. Lalang is a particularly noxious kind of weed and can hold its own against any competition from other plants once it is firmly established. Possessed of great vitality and the power to spread with great rapidity, it makes a dense growth about three feet to four feet in height, while its rhizomes burrow in the soil to a depth of one to two feet. The only known way of clearing land from this weed is to dig right down to the lowest roots and to remove all the root-stocks by forking and hoeing; this operation is very expensive and costs up to £10 an acre. In many of the older oil palm estates the land was clean-weeded, with the result that the lalang was able to get well established with deplorable consequences.

Soil Erosion.—The bad effects of clean weeding were not confined to the intrusion of lalang, for in some areas to which the lalang did not spread it became obvious that the oil palms were not flourishing with their customary vigour; this was rightly put down to loss of fertility due to soil erosion.

Green dressings.—Quite recently, however, a remarkable change has come over the methods of cultivation employed in Sumatra. The standard method of cultivation is no longer clean weeding, which has been entirely superseded by the use of suitable green dressing in hevea, oil palm, and coconut estates. The two problems of how to control lalang and how to conserve the soil have thereby been solved. The older estates have taken the middle course of just allowing the weeds to grow and then to cutlass them periodically, but this method is only partly satisfactory due to the presence of the exhausting lalang.

At present there are only two green dressings which have gained popularity. The first is *Calapogonium mucunoides*, which is a sun-loving plant, and is generally grown under young trees, and especially in new clearings. This dressing makes a thick, dense, but not rank, covering of from two to three feet in thickness. It is very quick growing, and being a vine requires a certain amount of attention to prevent its climbing young trees. *Calapogonium* cannot overcome lalang, but effectually prevents it from spreading. The second important green dressing is *Vigna oligosperma* (Dolichos Hosei or Vigna Hosei), which is a shade-loving plant and is generally used under established trees. This dressing makes a very even cover

a few inches thick. These two legumes are of great value to Sumatra; they have completely altered the cultivation methods employed for oil palms and other perennial crops. It was no uncommon sight to see large areas of established hevea and oil palm estates covered with a uniform cover of one or other of these dressings, in fact their widespread use is the most striking feature of the Sumatra estates compared with both Malaya and Ceylon.

Many estates are testing out new kinds of green dressings with the object of discovering species which are even better. Amongst these may be mentioned *Centrosema plumieri*, which has also been discovered independently growing wild in the bush near Benin and is now in general use on the Government plantations at Benin and Umuahia, and *Indigofera endecaphylla*, which is a non-climbing cover that is doing very well in the gardens of the Thee Proefstation, Buitenzorg, Java, and at Peradeniya, Ceylon. Other groups of plants, such as *Tephrosiae*, *Cassiae*, and *Crotolariae* are receiving attention. *Mimosa invisa* which at one time was used extensively, is no longer considered suitable, owing to difficulties of management due to its spines which injure the coolies' legs.

Methods of Establishing Plantations.

The modern method therefore of establishing the crop is to utilise green dressings and not to clean weed. The usual method is to plant a green dressing, usually Calapogonium, immediately the forest is cleared and burnt. Any patches of lalang which appear are entirely eradicated by deep digging. The calapogonium cover is maintained while the trees are young, and will probably be kept up during the life of the palms. In this respect the oil palms differ from hevea in that the shade thrown is not so dense, for calapogonium will not thrive under a full canopy of hevea trees and *Vigna oligosperma* has to be brought into requisition.

Another method, which is very much criticised by planters who are using the first method, is to clear wide lines of lalang, and interplant the spaces in the lines between the palms with a green dressing. These lines are widened each year by further hoeing until, by the time the palms cover the land, the interlines and the lalang have been completely effaced. In a plantation on which this method was observed, the planting lines were three metres ($9\frac{3}{4}$ feet) in width in the first year and eight metres ($26\frac{1}{4}$ feet) apart; the interlines of five metres ($16\frac{1}{2}$ feet) would, it was stated, disappear in five years. The advantages claimed from this method were speed of planting, and a more even distribution of expense during the non-productive years. This method is being exploited on a large scale on certain estates by one of the largest companies.

Several other semi-jungle methods have been tried by some estates, including the spot system in which four metre circles only were kept clear of lalang, and the line method in which the bush trees were not stumped and the bush allowed to develop again, but in all cases, with the sole exception of the line method in lalang just described, the estate managers have reverted to the straightforward method of completely clearing and covering the land entirely with calapogonium.

Pruning.

Severe pruning of leaves was originally recommended and practised in Sumatra, but was shown by the A.V.R.O.S. staff to be definitely harmful. This practice was discontinued some years ago and is no longer followed on any estate. The result of severe pruning was to increase the rate of vertical growth, to weaken the palm, and to diminish the yield. On all the older estates may be seen palms in which the girth of the trunk had gradually decreased as a result of severe pruning and had gradually resumed its normal size after cessation of the practice. The general principle followed now is to remove only the supporting leaves of the bunches at harvest time, which is a necessary operation in order to be able to remove the bunches.

Artificial Pollination.

In Sumatra a great deal of attention has been paid to the possibility of increasing the yield by artificial pollination. Early observers noted that many bunches were very imperfectly filled with fruits, and early trials in pollinating the flowers resulted in greatly increased yields. Practically every estate in Sumatra has employed this operation often over a period of years, and in every case has found that the average yield per acre has increased up to as much as fifty *per cent.* At Serdang Experimental Station, Malaya, a striking contrast was observed in an avenue of palms, in which those on one side of the road had been pollinated artificially and those on the other side had received no attention; judged purely by appearance the increased yield due to pollinating was over 100 *per cent.* But while it is generally recognised that artificial pollination will result in bigger yields, experience has shown that continued application of this practice results in a rapid exhaustion of the trees, especially when they are young. For this reason the practice has been discontinued in some cases or maintained only in a modified form.

The object of the Sumatra planter is to get as large a yield as possible without overtaxing the vitality of the trees or the resources of the soil. In most cases a limited method of direct pollination

meets the case, in which each area is treated twice a week only, or for a whole week in each month. On one estate a pollinating machine was used by which pollen was blown into the air in small quantities. These machines were strapped on the backs of coolies who walked through the interlines working the bellows which puffed out the pollen. The idea of all these methods is to adjust the crop to what the palms can bear. It is generally recognised that some degree of artificial pollination is necessary, but it is clear that the best method for a planter to follow can be found out by experience alone. With improved methods of cultivation, and when manuring is undertaken on an increasing scale, the palms will be able to bear a greater amount of pollination with satisfactory results and without injury.

Manuring.

The subject of manuring is receiving a considerable amount of attention in Sumatra: the A.V.R.O.S. Experimental Station and practically all the estates are conducting manurial experiments. In areas where the palms are not growing too well, these trials are planned with the object of discovering any soil deficiency, but most of the investigations are designed to throw light on the general principles of manuring oil palms, so that systematic manuring can be applied to healthy oil palms on a large scale with a consequent average increase in yields. Experience has shown that the palm tree is liable to bear fruit so heavily as partially to exhaust the resources of the soil; hence its prolificness has to be curbed by a modified application or the complete omission of artificial fertilisation. Again, the advantage to be gained by planting improved palms would be reduced by the lack of a sufficient amount of electrolytes in the soil. The Dutch planters are well aware that the maximum yields to be obtained by complete artificial fertilisation and the full use of superior varieties will probably result in the impoverishment of the soil and that knowledge of the requirements of oil palms on different types of soils is a *sine quâ non*. Dr. Ficendey's investigations (3) tend to show that an application of nitrogen is usually attended by good results, especially on poor soils.

Present Yields.

The subject of yield is of prime importance, as the successful future of the plantation industry rests to a large extent on the maintenance of high yields of oil per acre. It was found difficult to obtain figures of yield from commercial estates in Sumatra, but those that were obtained, together with figures from other sources, give a very fair indication as to present and possible future yields.

A.V.R.O.S. Experimental Station published estimated yields in 1922, which had been calculated and estimated from individual tree yields of avenues and ornamental palms. This method is admittedly liable to gross exaggeration, and these estimates have been regarded as extremely optimistic by workers in West Africa. Allowing an extraction efficiency of ninety *per cent.* these figures were :—

Age of Palm.	Pericarp oil per acre.
4th Year	702
5th to 7th „	1,404
8th to 10th „	1,579
11th to 20th „	2,086
21st to 30th „	2,086
over 30 years	1,230

In 1923, Monsieur Ives Henry (10), Director of Agriculture, French Indo-China visited Sumatra. He obtained yield figures from nine estates and concluded that the maximum yield for ordinary soils is 1,070 lb. and for good soils 1,516 lb. of palm oil per acre. An average yield according to his graphs (Plantation No. 1) and the best yield (Plantation No. 5) are given below :—

PERICARP OIL LB. PER ACRE.

	Plantation No. 1.	Plantation No. 5.
5th Year	170	—
6th „	330	240
7th „	560	420
8th „	1,250	1,070
9th „	1,050	1,550
10th „	1,000	1,470
11th „	880	1,270
12th „	—	1,050

The yields of two estates in Sumatra are given below. The former area consists of fifty-four acres of " Deli " type planted forty-six per acre on first-class soil, but no systematic cultivation or artificial pollination had been done. The second is a property of 410 acres of " Deli " type planted thirty-four per acre on average soil, but the palms had been seriously overpruned in earlier years and had been hand pollinated in 1921, 1922 and 1923.

PERICARP OIL LB. PER ACRE (CALCULATED AT 30% OIL TO FRUIT).

Year.	Estate No. 1 (*see* Table No. 3).	Estate No. 2 (*see* Table No. 4).
1923	1,456	—
1924	1,720	1,032
1925	1,711	1,919
1926	1,375 (Jan. to July inclusive)	856 (Jan. to July inclusive)

Below are given average yields for plots on two estates in Malaya. For the first estate, yields have been selected from typical plots of the three main plantings which have come into bearing; the feature of these figures is the earliness with which the palms have come into bearing. The yields of the second estate are interesting on account of the high yields obtained on some plots.

ESTATE NO. 1 (*see* TABLE NO. 5). PERICARP OIL LB. PER ACRE.

Year.	PLOT 3.	PLOT 6.	PLOT 8.
	Planted 1921.	Planted end of 1921.	Planted 1922.
1924	347	71	—
1925	953	789	263
1926 (Jan. to Sept. inclusive)	948	1,206	816

ESTATE NO. 2 (SEE TABLE NO. 6). PERICARP OIL LB. PER ACRE.

AVERAGE.

TREES UP TO EIGHT YEARS AGE.

Year.	Plots 1–7.	Plot 4.	Plot 6.
1923	1,231	2,555	1,636
1924	1,474	2,284	1,860
1925	1,413	2,100	1,444
1926 (Jan. to June inclusive)	493	562	612

(Note that the heaviest bearing occurs in the second half of the year).

By collating the figures already given, we get a very interesting comparison :-

PERICARP OIL LB. PER ACRE,

		A.V.R. O.S. Estimate.	IVES HENRY'S FIGURES.		SUMATRA.		MALAYA.			
							No. 1.		No. 2.	
			No. 1.	No. 5 best plot.	No. 1.	No. 2.	Plot 4.	Plot 6.	Plots 1–7.	Plot 4 best plot.
2nd	Year	...	...	...	...	...	...	...	...	...
3rd	,,	...	...	...	...	...	...	71	...	...
4th	,,	702	...	...	...	...	347	789	...	...
5th	,,	(1,003)	170	...	...	...	953	1,600*	...	...
6th	,,	1,404	330	240	1,456	...	1,200*	...	1,231	2,555
7th	,,	(1,491)	560	420	1,620	...	...	...	1,474	2,284
8th	,,	1,579	1,250	1,070	1,711	...	...	...	1,413	2,100
9th	,,	(1,632)	1,050	1,550	1 900*	...	...	...	...	...
10th	,,	(1,885)	1,000	1,470	...	1,032	...	...	...	...
11th	,,	2,086	880	1,270	...	1,919	...	...	...	...
12th	,,	2,086	...	1,050	...	2,100*	...	...	...	...

(*Note* :—Figures marked * are calculated from the yields in the early months of 1926).

A considerable amount of information can be obtained from these figures. In the first place, some palms have actually given very fair yields at the rate of one-third of a ton of oil per acre in the fourth year after planting out. Average yields of well over a ton of oil per acre on large size plots of over fifty acres have been recorded. Except for Ives Henry's figures a yield of half a ton of oil per acre is the minimum yield obtained, while 1,400 lb. or five-eighths of a ton appears to be quite a reasonable average yield for estates at present.

The exception in the previous paragraph, namely the yields recorded by M. Ives Henry, is a subject demanding further attention. As the result of observations made in Sumatra, M. Henry (10) criticises the estimated figures given by A.V.R.O.S.; in addition to showing that the palms are coming into bearing at a later age, and that the maximum yield is much lower than expected, he points out that the maximum yield is reached in from seven to ten years after which it declines. It is clear from M. Henry's figures—the accuracy of which is not questioned for they are actual crop records obtained from estates—that the yields have in fact decreased in the way he points out. But there is a strong feeling in Sumatra that he did not stress the reasons for this diminution sufficiently, and a rejoinder to his article is likely to be published in the near future by Sumatra workers.

In the first place it appears unreasonable to expect that an oil palm, which in its native country lives to an age of fifty to 100 years, would attain to its maximum productivity at the early age of seven years. The probable reason for the decline in yield on the older estates is because the early planters did not know the correct methods of cultivation. "Clean-weeding" allowed lalang to get in and failed to conserve the soil, especially the humus; heavy leaf pruning in early years seriously taxed the resources of the palm, excessive artificial pollination of young palms brought them into bearing before they were strong enough to produce large yields without injury, and very highly productive palms were not manured systematically to maintain the soil in a high state of fertility. These are some of the early mistakes which were made, so it is not surprising that the yields of the early plantations have not in all cases been maintained. There is no reason why a good average yield per acre should not be maintained over a long period of years by modern methods of cultivation and suitable manuring.

Future Yields.

Most of the planters in Sumatra and Malaya regard a yield of a ton of oil per acre as a probable normal yield for the newer estates, but it is probable that this is an overestimate. At the same time when it is remembered that five-eighths of a ton is quite an ordinary yield for unselected, unmanured, and imperfectly cultivated palms, I should not be surprised if many of the newer estates give sustained yields of three-quarter of a ton of oil per acre. It is obvious from the way in which the Dutch are tackling all the problems connected with yield that they will leave no stone unturned to get the highest average productivity possible, for high yields go hand in hand with reduced cultivation, harvesting and transplanting costs per ton of oil out-put.

THE FACTORY.

In Sumatra, several new and well-equipped factories have been completed recently or are in course of construction. The machinery of all these factories was made by Krupp & Co. They are erected for an out-put varying from 5,000 to 10,000 tons of pericarp oil *per annum*. Of the eight largest factories operating at present, all of which use hydraulic presses, four are of the latest Krupp design, and in five cases benzene extraction is carried out as an auxiliary and final operation.

The methods of extraction are not identical in every Sumatran factory, but in each case the whole fruits are pressed after mashing in a "swing-box" press, and the remaining pulp is separated from the nuts in a rotary screen immediately afterwards. This pulp is

then subjected to a second pressing in a vertical frame press of greater capacity than the first press or to solvent extraction apparatus or to both in succession. Pressures vary from 100 to 300 atmospheres according to the degree found most suitable for the particular method followed by the factory. The efficiency of these factories, as shown by the percentage of oil recovered *per cent.* oil contained in the fruits, is claimed to be very near to 100 *per cent.*

British Machinery.

It was very disappointing to find that British machinery was not represented in Sumatra. Messrs. Krupp & Co., have certainly made great progress in designing and perfecting new machinery, and by experiments on a large scale have succeeded in co-ordinating the results of their investigations into efficient factories. Their success must obviously be attributed to their policy of employing resident engineers, with experience of sugar factories in Java, and of controlling and running their factories for a year before handing them over to their customers. No signs of enterprise are evident from English firms, with the one exception of Messrs. Manlove and Alliot of Nottingham, who are supplying factories employing the centrifugal method to estates in Malaya. The one factory of this type at present working in Malaya is giving satisfactory results, but it has not as yet found favour with the Dutch in Sumatra. The centrifugal method has been tested in some of the Sumatra factories with unsatisfactory results, and those, whose business it is to study the relative merits of extraction methods there, are unanimous in condemning the centrifuge as compared with the hydraulic press. My own opinion is that while the hydraulic press is suitable for the extraction of "Deli" type fruit, the centrifuge is a better proposition for the extraction of the present type of Nigerian fruit; this point will be mentioned again when the various machines are dealt with individually.

Progress in Machinery Development.

It is not intended to imply that the Dutch have reached finality in any of the problems of machinery and factory design. Many methods are still in the experimental stage, and consequently estates will not publish their figures, or disclose them in confidence, and their latest efforts are shrouded in secrecy. In the most recent factories the main points over which there have been differences of opinion have been settled for the time being, and their main design is not likely to be altered for some years. I cannot do better than describe the process of one of these up-to-date factories, and discuss the more important alternative methods in parenthesis as the merits of each operation are recorded.

Preparation of Fruit.

The fruit bunches are conveyed to the factory in steel basket trucks by rail. The trucks are raised by cranes, which record the weight automatically, to overhead rails, and packed into large cylindrical sterilisation chambers. Each truck can hold 800 kilogrammes (three-quarter ton) of bunches, and each chamber can hold six trucks. The bunches are there subjected to steam at a pressure of $2\frac{1}{2}$ atmospheres. After sterilisation the bunches are discharged from the trucks on to an elevator, which carries the bunches to the threshing machine, situated at the highest storey of the factory. In the threshing machine, the bunches receive a violent shaking by means of substantial striking arms which pass through rigid grids spaced at such an interval that the stalks cannot fall through. The fruits fall through the grid and pass through rotary screens below, which remove any small stalks which have managed to pass through the grid of the thresher. The large stalks are allowed to escape periodically by hand application to a lever.

Various methods are employed at other factories. In some cases the bunches were stored in field sheds and the fruits removed from the stalks by beating with coolie labour. One case was observed in which the bunches were treated in the mechanical stripper before sterilisation. In some factories the fruits were first sterilised in a steam oven, and in others the fruit was delivered straight into the malaxeur, where sterilisation eventually took place by heat. All three alternative methods are unsatisfactory, as a high degree of free fatty acidity results. There is no doubt that the method employed in the up-to-date factories is the best, for the free fatty acidity can be kept below two *per cent.* and the extra cost of transporting bunches is more than offset by the saving in the labour necessary to store the bunches in the field and remove the fruits from the bunches.

Malaxeur.

The fruits are next delivered by gravity to the malaxeur, in which they are heated and mashed, and from there they are expelled, again by gravity, to the first press. There is a malaxeur for each press, and in the case of the factory I am describing, a battery of four presses was in use. Each malaxeur is provided with a steam jacket, in which a steam pressure of four atmospheres is maintained; its internal measurements are $2\frac{1}{2}$ feet in diameter, and six feet in depth; its capacity is about a ton of fruit. The mashing is extremely thorough, and, in the latest model, a gauze, through which liquid oil may escape, is provided round the base. The special features of the malaxeur are two; in the first place it is continuous, *i.e.*, the fruit

progresses gradually from the top to the bottom as the fruit is discharged, and secondly the fruit is only subjected to the heat of the steam jackets, and is not directly exposed to steam at this stage.

First Press.

The press is of the swing-box type, so that while one cylinder is being filled, the fruits in the other cylinder are being pressed. The arrangement of the hopper to the malaxeur is such that a charge of equal weight is delivered each time; usually five plates are used, so that each cake is about three inches thick. By means of a sliding cover it is possible to give a first light pressing and add a further charge The twin press is operated by one man, who controls the filling, pressing, and discharging single-handed, and from twelve to sixteen charges per hour is the usual rate of working. The internal measurements of each cylinder is twelve inches in depth by eighteen inches in diameter; the capacity is sixty kilogrammes of fruit. Hence the output of the machine is three-quarters to one ton of fruit per hour. Pressure varies according to the general process followed and ranges from 100 to 350 atmospheres. The pressed fruits are transferred to rotary sloping cylinders of " expanded metal " for separating the remaining pulp or fibre from the nuts; the fibre falls through the mesh and the nuts move slowly down the cylinder to the terminal outlet.

Alternative methods to pressing have been tried in a number of factories, and, amongst these, there are three of major importance. " Etna " depericarpers, or machines of similar type, have been tried and universally condemned; Anderson expellers, or continuous horizontal screw presses, are receiving attention and are considered likely to yield satisfactory results eventually by some workers; and finally, there are the centrifugals, as exemplified in the factories supplied by Manlove & Alliot. It might be useful to give a comparison between the centrifuge and press.

Centrifugal.

The output of a forty inch centrifuge is about the same as the Krupp press, *viz.*, three-quarters to one ton of fruit an hour, although that of the centrifuge could be increased by employing power to raise the centrifuged fruits. The initial cost of the centrifugal is lower than that of the press. With Sumatran fruit the efficiency of extraction is slightly lower for the centrifuge; this was confirmed by Barnes (15) in his experiments at Wembly, and again when he showed that further oil could be extracted, after centrifuging, by pressure at 350 atmospheres. With the centrifuge, steam has to be applied in order to get an efficient extraction, with the result that a

prolonged drying is necessary before the pressed fruits can be depericarped; with the Krupp press, no steam is applied to the fruits after sterilisation, so that depericarping can be done immediately after pressing, and shrinkage of the kernels from the shells, which is essential for efficient cracking, is proceeding throughout the whole process. It is a matter for experiment to decide whether it would not be better to centrifuge without steaming and obtain the residual oil by solvent extraction.

Because the press has found favour for the extraction of Sumatran fruit, it does not follow that it will be equally suitable for Nigerian wild fruit. Comparative analyses of the fruit by weight and by volume are approximately as follows:—

	Sumatra.	Nigeria.	Sumatra.	Nigeria.
Pericarp Nuts	60 lb.	40 lb.	70 cc.	45 cc.
Fruits	40 „	60 „	30 „	55 „
	100 lb.	100 lb.	100 cc.	100 cc.

A simple calculation from these figures will show that in pressing Sumatran fruit the whole of the interstices between the nuts are still filled with pulp under pressure even when ninety *per cent.* of oil has been pressed out, while with Nigerian fruit these interstices are barely filled by the original quantity of pericarp contained in the fruits, and the pressure is taken by the nuts as soon as a small quantity of oil has been pressed out. This contention could be tested by adding to Nigerian fruits, such an amount of fibre as would make the proportion of fibre to nut similar to that of Sumatran fruit. By adding the fibre from 125 lb. of Nigerian fruit to 100 lb. of Nigerian fruit, the resultant mixture would, after mashing, approximate to Sumatran fruit, and if pressed, would probably give results equal to that obtained with Sumatran fruit. As a corollary, it is possible that Nigerian factories exploiting the " press " method might find it advisable to re-introduce part of the fibre from the separator to the malaxeur by means of an extra travelling way.

Second Press.

The second press to which the fibre is conveyed after depericarping is of the vertical frame type and of greater capacity than the first press. It is provided with a malaxeur for heating and mashing the fibre. Pressures ranging from 100 to 300 atmospheres are used varying with the subsequent treatment followed.

Benzene Extraction.

The benzene extraction apparatus seen was made by A. Borsig, Berlin-Tegel, Germany. It is complicated and consists of the following parts:—

(*a*) extraction vessel;

(*b*) still with condensing arrangements;

(*c*) separating towers for separating traces of benzene from palm oil;

(*d*) benzene purifiers.

The apparatus has to be mounted in a separate building well away from the factory or other sources of danger from fire. A description of the method is given in an A.V.R.O.S. publication (14). In the oil extraction plant observed there were only two extraction vessels, but the best number is four or five. Each extractor held 1,550 lb. (7/10 ton) of pulp. The extraction claimed was 300 lb. of oil from 1,550 lb. of pulp, with a loss of benzene of 40 lb. The apparatus required very little supervision.

Kernel Recovery.

The depericarped nuts are carried by worm conveyer to a rotary drier, and thence to centrifugal crackers. Nuts which fail to crack are separated from the kernels and shells by rotary screens and are returned to the crackers. A roller cracker is used in some factories, especially for nuts which fail to crack in the centrifugal crackers, but it has a slower output and requires the nuts to be drier to avoid damage to the kernels.

The kernels are separated from the nuts by an underwater shaker in a water tank for which an efficiency of ninety-seven *per cent.* separation is claimed. A steel basket into which the shells and kernels are fed moves rapidly up and down inside the water tank; the bottom of the basket slopes slightly downwards to the front end, and the shells and kernels are impelled forward by the up and down motion of the basket, and prevented from travelling too quickly by shallow cross buffers. As the mixture proceeds, the kernels, which are lighter, tend to rise and form a layer above the shells, and on arrival at an oblique overhead partition are diverted to one side. The shells pass under the partition and are eventually thrown out of the shaker whence they are recovered from the water by endless belts and conveyed to the furnaces. The kernels have a further obstacle to negotiate in the form of a small partition, over which the shells are unable to jump. The kernels jump over into the partitioned compartment whence they are recovered from the water by

endless belts, conveyed to driers, and finally graded and bagged. This machine requires no supervision and the output is stated to be three tons of kernels per day.

The method in general use at the older factories is the mud-bath process. The brine tank process has been definitely discarded owing to the high price of salt. The underwater shaker just described is easily the best solution of the problem at present, and will probably remain so until an efficient machine for separating the kernels from the broken shells in a dry state has been invented, built, and proved.

Oil Purification.

Four grades of oil are obtained during the process of extraction, namely first quality oil from the first presses, second quality oil from the second presses, residual oil extracted by benzene, and low grade oil recovered from scums and emulsions. These grades are packed and shipped separately. The purification apparatus and machinery in a first-class factory include :—

(*a*) washing tanks to which steam can be injected and water added;
(*b*) setting tanks for the separation of the oil and water;
(*c*) steam-cased vats for the drying of the separated oil by heating to 105°C;
(*d*) horizontal scum presses for the filtration of the dried oil to remove solid impurities;
(*e*) centrifugal separators for the recovery of oil from the emulsion which forms between the oil and the water in the settling tanks.

These are the main processes followed at the modern factories, but in most of the older factories the oil is purified by washing, settling and decanting alone. In the newest plants most elaborate arrangements have been made for the recovery of every particle of oil from every possible source of loss.

The centrifugal method of purifying oil recommended by Barnes (15) has received attention, but as yet it is only regarded as a useful adjunct to the method now in use. The main disadvantage of the centrifuge was stated to be the frequency with which the machine had to be dismantled in order to clean the bowl; in a scum filter press, if one of the sections becomes clogged or fails to function properly, this does not affect the other fifteen sections which continue to work as usual. One disadvantage of the filter press is that the oil has first to be freed from moisture, as otherwise the water will clog the canvas filter cloth in a very short time; for centrifugal purification the oil has first to be freed from solid matter as much as

possible in order to prevent rapid clogging of the bowl. Hence, while it is realised that the centrifuge has distinct possibilities, the Dutch have pinned their faith to the filter press, which is universal in the sugar factories of Java and provides a rapid and efficient method of oil purification.

Packing and Transport.

The oil is conducted by pipe into storage tanks, whence it can be transferred to railway tank waggons for shipment to the port. Usually two tanks of a capacity of $3\frac{3}{4}$ tons of oil are carried on each railway waggon. On arrival at the port each tank is lifted bodily by crane and the contents emptied into the oil tanks of the steamer. Plans are now in hand for the erection of large tanks at the port of shipment in which oil from the estates will be stored until arrival of the tank steamers. The chief difficulty of this method was stated to lie in the fact that the oil solidifies on the voyage to Europe and cannot be unloaded easily, but it is believed that this difficulty has been overcome.

In the Malaya factories and the older Sumatra factories the oil is shipped in 40-gallon casks. This method is very expensive and costs up to £6 a ton of oil. At some factories low grade oil is shipped in iron drums.

Recapitulation.

The various methods and processes most likely to be successful have already been discussed, but a recapitulation of the points which have been found by Dutch experience to be the best, may be useful:—

(*a*) *Preparation of Fruit.*—Rail transport of whole bunches to the factory bunch sterilisation without removal from the rail trucks.

(*b*) *Oil Recovery.*—Double pressing (whole fruit and partly exhausted fibre) in hydraulic presses after "dry" mashing.
Possible application of horizontal screw press or wringer as a substitute for hydraulic press. Benzene extraction for complete recovery of residual oil.

(*c*) *Kernel Recovery.*—Centrifugal cracking of nuts. Separation of kernels from shells by underwater shakers.

(*d*) *Oil Purification.*—Scum presses for final purification of oil after partial cleansing in steam tanks.

(*e*) *Tacking and Transport.*—Bulk transport of oil to port, bulk storage at port, and bulk shipment in tank steamers.

At present there is a complete dearth of *accurate* information with regard to practically every step on the process of manufacture. The relative merits of centrifuge and press, the efficiency of different methods of purifying oil, the effect of varying the time taken in various operations, and the control of the furnaces, are a few of the points which need study; private firms in Sumatra who have already solved these questions to their own satisfaction, are not likely to publish their results yet. It is essential that research of this description should not end in laboratory work and small scale extraction; only by following up the results of such work with units of a size that are suitable for a large factory can really satisfactory proof of the efficacy of an innovation be obtained.

Construction and Control of Factory.

Apart from the principles on which the various machines are based, the design of a first-class factory depends very largely on the degree of thoroughness with which every detail has been thought out and executed for its efficiency. In this connection, the latest Krupp factories are surprisingly free from those irritating details which abound in factories which are a conglomeration of machines and not a co-ordinated whole. This work of co-ordinating and balancing the machinery to ensure that the factory will run smoothly without "bottle-neck" units has been carried out by resident engineers. Observation of many factories in the East clearly demonstrated that such work cannot be done efficiently by an amateur and that factory design and factory control require the services of highly specialised engineers and chemists.

In Java, eighty-five Dutch sugar factories have adopted a system of factory control. Each factory sends a mass of figures once a fortnight to a central station at Pasoerean which works them out and publishes them a fortnight later. From this publication, which runs into seventy pages of figures, the factory manager can see how much sugar he has lost, in the filter presses, molasses, begasse and so on, how much fuel and water used (altogether seventy-two figures are given for each factory), and he can compare his losses with those of other factories. With this information he is able to concentrate on those units in his factory whose efficiency compares unfavourably with that of other factories. In this way a very high average efficiency has been obtained in the sugar factories of Java. Machinery has been improved, factory management has increased in efficiency, and the cost per ton output of sugar has been reduced. The average amount of sugar recovered *per cent.* sugar in cane varied from 91.7 *per cent.* to 97.3 *per cent.* for the various types of factories in the year 1925, compared with 91.2 *per cent.* to 93.6 *per cent*, in 1924. Hence,

when the shroud of secrecy is removed from the operations of the palm oil factories in Sumatra, it appears probable that a similar system of factory control will be instituted and will be attended with equally satisfactory results.

LABOUR COSTS.

In the preceding pages I have omitted all reference to the costs of a Sumatran estate. From a mass of figures obtained during the visit it is possible to come to some very fair conclusions as to the costs of production, although in no cases could actual figures be obtained from the larger estates. The labour cost is a very big item in the expenditure, so it would be well first to arrive at some figure for the cost of a man day. The actual pay of indentured coolies is 9½d. a day for a man and 8½d. for a woman, but when the cost of recruitment and repatriation, the provision of rice, erection of living quarters, medical attention and so on, are added to the daily pay, the total cost is nearly 1s. 6d. for the labour of a man day. Some times "free" coolies, *i.e.*, those who are engaged on casual day labour, are employed at the rate of from 10d. to 1s. for men, and 6d. to 8d. for women. So it appears that the average all-in cost of a coolie day including all the items above and also the cost of European supervision in addition, is from 1s. 3d. to 1s. 9d. a coolie day when an allowance is made for a percentage of free coolies and women. The cost of European supervision as far as plantation work is concerned may be gauged from the fact that on the largest estates one European assistant supervises about 1,000 acres.

Capital Cost.

The cost of bringing an acre of oil palms into bearing is stated to have averaged £30 an acre in Sumatra, excluding the factory. The large size plantations, however, which are now being established are costing less than this. An examination of the various estimates and costs studied shows that a fair cost in man days per acre is as follows:—

	Man days per acre.
Clearing, including felling, burning and planting cover crop	70
Establishing, including nurseries, lining, holing, carrying seedlings and planting	10
Miscellaneous operations, including draining, terracing, removal of lalang and light roads ...	70
Upkeep for four years	70
	220

Assuming that the clearing is done by contract with " free " labour at 1s. per man day and the remaining items at 1s. 6d. per man day, and allowing an additional small percentage for supervision the total cost excluding interest on capital is £17 10s. per acre. To this must be added about £3 10s. an acre for the light-railway track, making a total of £21 an acre.

The capital cost of a factory in Sumatra is about £10 per ton annual output of pericarp oil. This figure includes all items connected with the factory and all adjuncts such as office, chemical laboratory, railway lines and rolling stock, store rooms, and workshops. Assuming a yield of 5/8th ton of oil to the acre, then the capital cost of the factory per acre is about £7, making a total capital cost per estate of £28 per acre. To this figure might be added a maximum of £4 to cover the cost of interest on capital for the years during which interest at ten *per cent.* on the capital is not covered by profits. With a yield of 5/8th ton of oil per acre, therefore, it is clear that the capital cost per ton of oil production is about £50.

Cost of Production.

It is convenient to calculate the running expenses on production of oil rather than on the acreage. Labour is calculated at 1s. 6d. per man day and the yield of oil per acre is assumed to be 5/8th ton. It is stated that at present Sumatran oil is being delivered in Europe at a cost price of £24 per ton of oil, excluding interest or profits on the capital invested. This again is thought to be a higher cost than that at which the new estates are capable of producing oil. The following is considered to be a fair estimate of the costs for a first-class plantation in full bearing:—

	£	s.	d.
Plantation upkeep, including weeding, maintenance of roads and so on, control of pests, artificial pollination, etc.	1	16	0
Cutting bunches and carrying to road or railway	0	15	0
Transport of bunches to factory	0	7	0
Plantation supervision	0	14	0
Factory costs	2	10	0
Freight to local port	1	8	0
	£7	10	0

	£	s.	d.
Packing	4	15	0
Steamer freight to Europe including harbour dues	5	15	0
Expenses of sale	2	10	0
	£13	0	0
Total	£20	10	0

The cost price of delivery to England is thus shown to be £20 10s. per ton of oil. This I do not believe to be a rock bottom figure, for the cost of packing is still capable of some reduction and the yield per acre might well be greater than 5/8th ton of oil. If the oil were sold for £30 10s. a ton, the profit obtained for the palm oil alone would be £10 on a capital cost of £50, or twenty *per cent.*

The kernels may be regarded as a subsidiary by-product. The cost of delivering a ton of kernels to Europe is approximately as follows:—

	£	s.	d.
Factory costs	1	10	0
Packing	0	13	0
Transport to local port	0	12	0
Freight to Europe including harbour dues ...	3	10	0
Expenses of sale	1	10	0
	£7	15	0

If the kernels were sold for £19 5s. a ton, the profit obtained for a ton of kernels, viewed as a by-product, would be £11 10s. or £2 15s. for every ton of palm oil produced.

While there is evidence that some estates, especially the older ones, are more heavily capitalised, or obtain lower yields that those assumed, or make a lower profit per ton of produce due to higher running expenses, I believe that the figures given represent a fair statement of the low costs that can be approached by a new large estate in full bearing in Sumatra.

FUTURE OF THE SUMATRAN OIL PALM INDUSTRY.

The future of the palm oil plantation industry is still uncertain, but it must be remembered that when the present plantations, which cannot be far short of 100,000 acres in area now (June, 1927), are in full bearing, they will be producing some 50,000 to 75,000 tons

of oil *per annum*—a quantity which is within measurable distance of the total present export from West Africa.

Natural conditions are distinctly advantageous, the variety is excellent, the soil and climate are extremely suitable, the palm is remarkably free from disease, plenty of suitable land is available on reasonable terms of price and lease, and efficient labour is plentiful and comparatively inexpensive. The fact that a large number of specialists are concentrating on the entirely new industry of oil palm culture and palm oil extraction has already led to better farming, bigger yields, more efficient extraction, and cheaper marketting: hence progress on these lines is likely to continue. It is considered that the price of palm oil is not likely to decline greatly, for palm oil forms a very small proportion of the world's supply of vegetable oil (for which the world demand is increasing) and new uses for palm oil are likely to be found.

But the industry's greatest safeguard lies in the fact that its main product is a very high grade oil. The latest factories produce oil of a maximum content of three *per cent.* free fatty acid. This is likely to be a matter of importance when high grade oil is produced in large quantities, for it is possible that a special market for the manufacture of edible solid fats will be created, and the difference in price between high quality oil of standard purity and low grade oil will then be greater than it is at present. The factories in the East will be in a position not only to supply oil on contract, but also to guarantee that the oil delivered will be of specified high quality, with, for example, a free fatty acid content of less than three *per cent.*

In the case of the industries, quinine and sugar, the Dutch have gained a pre-eminent position within late years. Their success has been due to efficient cultivation, manufacture, and marketting methods. The improvement in yield per acre with economy has been largely the result of first-class scientific research. As an example may be cited the case of the sugar-cane varieties in Java which have almost completely changed within the last ten years; the successful breeding of superior canes has been largely responsible for the increase in yield per acre from four tons in 1915 to five tons in 1925. To give some idea of the thoroughness of the work; 1,500 experiments, each one laid out on the chess-board system, were carried out on the Java sugar estates by one branch of the Pasoeroean Sugar Experimental Station in 1925.

The efficiency of manufacture in the case of sugar has resulted from the complicated system of mutual factory control already mentioned. But while improvements in agricultural methods and factory development have led to desirable results, it is probable that marketting efficiency has been of even greater importance. The

output and price of Java quinine are governed by an agreement between grower and market, and all the Java sugar is sold by a committee or "cartel" appointed by estates, the proceeds from each sale being divided proportionately amongst the estates. Methods similar to those which have been found so successful in the case of sugar and quinine may assist the Dutch to gain a pre-eminent position in the case of the oil palm plantation industry.

It must be admitted therefore, that the Sumatran oil palm industry appears to be in a very sound position, both agriculturally and commercially. Sceptics assert that the plantations are over capitalised, or that the yields will not be maintained, but neither contention can be supported by facts. As far as I can see, the Sumatran industry has only one disadvantage as compared with the West African industry, namely that the distance from the world market ports of either Liverpool or San Francisco is 8,000 miles, or twice as far as the distance from Lagos to Liverpool. Whether the present rate of expansion is likely to be maintained is of course uncertain, but it does not seem unreasonable to assume that the romance of the oil palm industry will be comparable with that of rubber in Malaya, or of tea in Ceylon. The industry lends itself admirably to the exercise of those talents which the Dutch have displayed in other cultures requiring sound organisation, painstaking research, and thorough methods. It is remarkable that it should owe its inception to the imagination of one who "observed how exceedingly well the oil palm grew in Sumatra compared with West Africa."

APPLICATION TO NIGERIA.

The chief object of the visit to the East was to obtain information to assist the Government in formulating a policy with regard to the future of the oil palm plantation industry. The question as to whether the palm oil industry is destined to pass from the phase of being largely a casual forest industry to that of a systematised plantation industry, or whether a village industry of peasant proprietors can stand up against an organised and scientifically controlled system of capitalised plantations and factories, are both of vital importance. Rubber, tea and quinine, are examples of forest crops which have been converted into capitalised industries, while cocoa, coconuts and cotton are being grown more and more by peasant proprietors. None of these crops furnishes a case exactly analogous to the oil palm, but the general inference is that a system of small holdings is unable to compete with large plantations when expensive factories are an essential for efficiency. The Sumatran factory extracts three times as much oil from a given weight of fruit as the Nigerian natives are able to obtain by their laborious

methods. The real danger to the Nigerian industry is not that the cultivation will disappear for the use of palm oil is firmly established in Nigeria, but that the price of low grade oil will be so reduced that it will not pay the Nigerian extractor to produce the oil for export. This will mean a loss in export trade, with a consequent decrease in revenue and diminished wealth.

Central Factories.

The provision of central factories, which was recommended by the Director of Agriculture in 1922, would of course alter the whole situation. The cost of capitalising an efficient system of factories in Nigeria would be too high for Government to embark upon the task, and for this reason it seems certain that private capital must be enlisted. The 1925 production of palm oil from Nigeria was about 130,000 tons; the capital cost with this output would be over £1,000,000.

With regard to the size of such a factory, a capacity of four tons of fruit an hour is considered to be the smallest for economical working in Sumatra, but in Nigeria there are other factors that have to be taken into consideration, more especially the transport of fruits to the factory from scattered oil palm areas, and possibly a smaller size of factory might be a more economic unit.

"Nucleus" Plantations.

The factories of Java, Malaya, Sumatra and Ceylon for the preparation of tea, sugar and rubber are all controlled by the plantation owners. These factories frequently buy raw material from owners of small holdings to mutual advantage, but this bought produce is merely supplementary to that grown on land owned and worked by the factory. In this way small holders have been encouraged and a large proportion of rubber in Malaya and tea in Ceylon is now produced by them. In no case does the factory owner rely entirely on the independent support of peasant proprietors. It is extremely doubtful therefore whether capital would be invested in expensive factories if the whole source of the palm fruit was the forest, or even if the palm was cultivated on small holdings outside the control of the factory. An oil palm industry in Nigeria in which small holdings, plantations and factories were in existence, side by side, would in my opinion be in a very strong position and well able to stand competition from any quarter. The improvement of groves, the dissemination of good varieties, and improved methods of cultivation would quickly follow, while the potential wealth of the palm forests would eventually be tapped. But more important than all, Nigeria would then be in a position to supply oil of comparatively

high quality. I think that the small holdings should still constitute by far the greatest part of the industry, but consider that they are at a great disadvantage in being denied the educative value and commercial assistance of properly run plantations and factories.

As regards the minimum size of such a concession, 5,000 acres is regarded as the smallest profitable size for an estate in Sumatra, and all the latest concessions are at least 12,000 acres in area. In the case of " nucleus " plantations for Nigerian factories, however, a smaller area than this should be sufficient.

Conclusion.

In conclusion, I should like to tabulate some of the special features of the Sumatran industry :—

(*a*) Excellence of the " Deli " type of oil palm.

(*b*) Improvement by selection.

(*c*) Rapid improvement in cultivation methods.

(*d*) Widespread use of green dressings.

(*e*) Progress in machinery development.

(*f*) Efficiency of the latest factories.

(*g*) High quality of oil.

(*h*) Bulk transport of oil.

Progress on similar, or divergent, lines in Nigeria is not possible if European enterprise is confined to trading in low quality oil. On the other hand, if a study of the methods which have been found to be successful in Sumatra find expression in British enterprise in Nigeria, there is still hope for a successful future to the Nigerian oil palm industry.

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LIST OF ESTATES VISITED.

12th August, 1926	...	Boekit Rata	Sumatra.
13th „ „	...	Medang Ara	„
— —	—	Selele	„
14th „ „	...	*Soengei Lipeot*	„
16th „ „	...	*Karang Inoue*	„
17th „ „	...	*Pantai Kiara*	„
18th „ „	...	Semadan	„
23rd „ „	...	*Mata Pao*	„
24th „ „	...	*Rambong si Alang* ...	„
25th „ „	...	Bah Bajoe	„
26th „ „	...	Nijkerk	„
27th „ „	...	Poeloe Radja	„
— —	—	Aek Loba	„
— —	—	Goenoeng Malajoe ...	„
30th „ „	...	*Tanah Itam Oeloe* ...	„
— —	—	*Tanah Gamboes*	„
6th September, 1926	...	*Marihat*	„
20th „ „	...	*Tjibolan*	Java.
10th October, „	...	*Hopeful*	Malaya.
12th „ „	...	*Elmina*	„
16th „ „	...	*Tennamaram*	„

The names of estates where factories, either small or large, were visited are in italics.

TABLE No. 1.

Sumatra :—

Year.	Area of oil palms planted		Percentage increase on previous year's total.	Percentage of total area at the end of 1925.	
	at the end of the year.	during the year.			
	acres.	acres.	%	%	%
1911–15	6,500	—	—	—	11
1916–20	22,400	—	—	—	26
1921	24,250	1,850	16	3	
1922	30,600	6,350	26	10	
1923	38,000	7,400	24	12	63
1924	46,800	8,800	23	15	
1925	60,350	13,550	29	23	
		Average ...	24%	100%	

Malaya :—

1913–15	10	—
1916–20	1,125	—
1921	2,067	942
1922	2,460	393
1923	4,320	1,860
1924	6,544	2,224
1925	9,694	3,150

Malayan figures from (7); Sumatran figures from (6) and (8).

TABLE No. 2.

YIELD OF TREE No. 249 ON SELELE ESTATE, SUMATRA.

Date of harvest.	Weight of bunches.	Weight of fruits.	Weight fruits to bunch.	Weight of nuts.	Weight of pulp.	Weight pulp to fruits.
	lb.	lb.	lb	lb.	lb.	%
12.9.25	70·3	39·7	56·4	9·5	30·2	76·1
12.9.25	90·3	47·2	52·1	10·8	36·3	77·1
18.10.25	52·6	32·6	61·9	5·1	27·5	84·4
21.1.26	86·4	53·3	61·7	13·4	39·9	74·7
5.2.26	57·9	41·9	72·2	9.7	32·2	76·8
13.2.26	78·0	47·2	60·4	13·0	34·2	72·4
17.3.26	74·5	43·2	57·9	16·5	26·7	61·7
7.4.26	71·6	37·4	52·3	10·1	27·3	72·9
30.4.26	61·0	33·9	55·5	8·4	25·5	75·3
20.5.26	37·5	16·5	44·1	4·4	12·1	73·3
20.5.26	43·4	18·0	41·6	4·8	13·2	73·1
11 bunches 36 weeks	723·5	410·9	56·7	105·7	305·2	74·3
1 average bunch	66 lb.	37 lb.	...	10 lb.	27 lb.	...

Percentage weight to	Stalks, etc.	Pulp.	Nuts.
Bunch	43·3%	42·1%	14·6%
Fruits	...	74·3%	25·7%

Figures of weights have been converted from kilogrammes to lb.

TABLE No. 3.

Yield in an estate in Sumatra.

544 acres of Deli type planted in October to December, 1917, planting distance 28′ × 32′; total number of palms 2,494 or 46 per acre.

Pericarp oil—lb. per acre.

Month.	1923.	1924.	1925.	1926.
January	...	145	173	204
February	...	103	160	162
March	114	...	103	186
April	108	...	39	92
May	...	90	64	245
June	169	108	130	193
July	275	131	117	293
				1,375
August	111	250	212	...
September	203	193	203	..
October	145	220	173	...
November	195	182	166	...
December	136	198	171	...
Totals	1,456	1,620	1,711	

Calculated at 30 per cent. oil to fruits.

TABLE No. 4.

Yield on an estate in Sumatra.

410 acres of Deli type, planted in 1913–14 ; planting distance 36′ × 36′. Total number of palms 13,760 or 34 per acre.

Pericarp oil—lb. per acre.

Month.	1924.	1925.	1926.
January	41	144	92
February	71	134	143
March	110	145	173
April	90	130	124
May	71	142	119
June	58	126	102
July	64	108	103
			856
August	64	139	...
September	94	167	...
October	109	208	...
November	126	203	...
December	134	273	...
Total	1,032	1,919	

Calculated at 30 per cent. oil to fruits.

TABLE No. 5.

YIELDS ON AN ESTATE IN MALAYA.

Deli type.

Plot No.	1.			2.			3.	
Date planted	21.5.1921			21.11.1921			25.5.1922	
No. of palms per acre ...	48			56			56	
Year.	1924.	1925.	1926.	1924.	1925.	1926.	1925.	1926.
			Pericarp oil—lb. per acre.					
January	8	21	58	...	31	134	7	62
February	14	28	74	...	19	111	5	61
March	23	62	87	...	22	105	5	71
April	32	89	101	...	28	89	9	64
May	63	101	104	...	26	96	13	63
June	47	96	141	...	45	118	15	89
July	46	142	191	...	99	188	33	159
August	31	103	115	7	99	202	21	149
September	26	91	77	5	97	163	29	98
			918			1,206		816
October	16	81	...	17	113	...	38	...
November	18	84	...	16	81	...	44	...
December	23	55	...	26	129	...	44	...
	347	953		71	789		632	

Calculated at 30 per cent. oil to fruits.

TABLE No. 6.

YIELDS ON AN ESTATE IN MALAYA.

Deli type—aged up to eight years.

Pericarp oil—lb. per acre.

Plot No.	1923.	1924.	1925.	1926. January–June.
1	359	1,622	2,130	827
2	724	964	1,320	340
3	1,918	1,550	1,010	366
4	2,555	2,284	2,100	562
5	1,120	1,091	732	306
6	1,636	1,860	1,444	612
7	307	948	1,158	436
8	593	1,721	2,190	863
9	463	1,252	1,668	614
10	...	488	1,746	864
11	...	551	1,556	1,004
12	...	221	926	616

Calculated at 30 per cent. oil to fruits.

Note that the cropping is nearly twice as heavy in the second half of the year.

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THE MAINTENANCE OF THE FERTILITY OF THE SOIL BY THE USE OF LEGUMINOUS CROPS.

By

T. Thornton, a.r.c.sc.

When one takes into consideration the fact, that the methods adopted by the Ilorin farmers have been evolved amongst a most primitive people, it is really surprising to find that the cultivation is of such a standard as it is. The only implement used is a hoe, made by their own blacksmith; they are only able to keep cattle in isolated places so that it has been impossible to obtain cattle manure; artificial manures are not known, and in any case, the farmers are too poor to purchase them; and green manuring, which has only been practised during comparatively recent years in Europe, is an entirely new thing to the native.

Until the last few years the only crops grown were such as were required locally, these being food crops with a little cotton. A definite system of rotation is practised, and the land is cropped from three to five years, until it is exhausted, when it is thrown out of cultivation for a number of years, said to be from four to six. The soil generally is a sandy loam very deficient in humus. Every dry season all the land not under cultivation is burnt, so that new land brought into cultivation at the beginning of the rains is only covered with such vegetation as has escaped the fires during the dry season.

The period of cultivation is during the rainy season. Although the rains usually commence in March, it is not safe to put in seed until April. Maize is sown in April and harvested in July and August. Guinea corn is grown in combination with maize, the seed being sown about one month later, and harvested in November and December. Yams are planted in October and November, and the farmer commences to dig the early varieties at the beginning of August, when they are only about half grown, and the later varieties in October. The rains ease off in October and finish early in November. The rainfall at Ilorin averages about fifty inches per annum, the wettest period is in September, and August is usually comparatively dry.

The native farmers have adopted a two year rotation :—

(1) Maize and Guinea corn.

(2) Yams and cotton, when cotton is grown.

(1) Maize and Guinea corn.

(2) Yams and cotton.

This is followed until the land is exhausted. Cowpeas widely spaced are usually grown with the Guinea corn, and sometimes with the yams. The land is cropped in this way from three to five years, according to the richness of the soil. With this heavy cropping, without anything being added to the soil, one is surprised that crops can be grown for such a period as five years. It is very unlikely that the later crops grown will pay the farmer for the labour which he expends on them.

The natural outcome of such a method is shifting cultivation. The shifting cultivation has caused large areas to be depleted of trees; and the heavy cropping of the land, and continued cropping until it is exhausted, must have meant much energy wasted in cultivating land which is unable to produce remunerative crops. In the year 1923, we tested a large collection of leguminous crops, both native and imported; two of these, mucuna and dolichos were outstanding in the large amount of vegetative growth produced. Each year since then these two have been tested in alternate half-acre plots on a ten acre block of land. Maize has been grown in the early part of each year as a test crop, followed by mucuna and dolichos, these being grown in the same plots as previously. Maize after dolichos has given slightly better results than after mucuna. Mucuna, however, produced more vegetative growth, and as a smother crop is far the best. At first it grows much more rapidly than dolichos, covers the land better, but dies down nearly two months before dolichos. In this experiment the plants were allowed to seed, and remained above ground until the beginning of the following rains. This is risky on account of fires, and if this were followed on the native farms, it would be impossible to prevent the vegetative growth from being burnt. Although not tested, I am of opinion that had both been cut down at the end of September, and then turned in before the end of the rains, the best results would have been obtained after mucuna.

In 1923 it was arranged to start a three years' rotation experiment, including mucuna in the series. The rotation arranged was :—

First year—maize and guinea corn.
Second year—yams and cotton.
Third year—mucuna.

Three-ten acre blocks were set apart for this purpose. Block B. plots 41-60, and Block C. plots 41-60, were planted with mucuna. Block A. 1-20, and Block C. 1-20 had already been planted with yams, and Block A. 21-60 was planted with maize and guinea corn. By this arrangement, ten acres would be planted with mucuna each year.

In 1925 a change was made, as it was thought that possibly the land was being overcropped by taking off four remunerative crops, and only giving back to the land one of mucuna. Mucuna was therefore substituted for Guinea corn. This arrangement has been carried out only in A. 1-20 and C. 1-20. The rotation thus became :—

Maize and mucuna.
Yams and cotton.
Mucuna.

It was found, that when mucuna was sown six weeks after the maize, it produced a very satisfactory growth, and did not appear to interfere with the maize. In 1926 another change was made. The results appeared to be working out so satisfactorily that it was thought unnecessary to continue keeping three ten-acre blocks under this experiment, and the acreage was cut down to three five-acre blocks. As one block was already in yams and another in mucuna, this change has only altered one-five acre section A. 41-60 and as the same original crops have been grown in eleven out of twenty of these plots, the returns of the whole block have been included in the table.

Plots.	No. of plots of 0·25 acre considered.	Crop.	Yield of Tubers Lb. Per Acre.		Average Increase.		Intermediate Crop.
			Year 1923.	Year 1926.	Lb. per acre.	per cent.	
A 1-20	20	Yams (Boki)	10,155	14,203	4,048	% 40	1923 late crop cotton.
C 1-20	12	„	13,306	14,896	1,590	12	1924 Mucuna utilis dug in in March, 1925. 1925 Maize followed by Mucuna dug in in November.
A 21-40	20	Maize and Guinea Corn	1,170	2,051	881	75	1924 Yams and Cotton.
A 41-60	11	Maize and Guinea Corn	1,322	1,921	599	45	1925 Mucuna dug in in November.

The experiment has now run four years. One block which started with mucuna has grown a crop of mucuna this last season, but as there will be no indication of the present fertility of the soil, until maize and guinea corn have been harvested next season this block must as yet be excluded from consideration.

Has the fertility of the soil been maintained? The results indicate that it has been more than maintained, take plots A. 1-20, Boki yams were grown in 1923 and again in 1926. Plot 7 was the

only one which gave a higher return in 1923 than in 1926. The average increase in 1926 over 1923 is 4,048 lb. of yams or nearly forty *per cent.* per plot.

In Block C. 1-20, only those plots can be compared which grew the same variety of yams. Here five plots out of twelve gave a greater yield in 1923, than was obtained in 1926, but there is an average increase of 1,590 lb. of yams or twelve *per cent.* per plot in 1926.

The results given for plots A. 21-60 show even greater increases for 1926 over 1923. This is no doubt due to the fact that the yields obtained are from crops following immediately after mucuna. Maize and Guinea corn were grown in 1923 and again in 1926; the combined returns of both these crops have been taken for comparison. In A. 21-40 no plot in 1923 gave results equal to those obtained in 1926. The average increase is 881 lb. or seventy-five *per cent.* per plot. In plots 41-60 only those can be considered which grew the same crop. Of the eleven plots which grew maize and guinea corn in 1923 and again in 1926, only one gave a higher return in 1923. In 1926 the increase was 599 lb. or forty-five *per cent.* per plot.

It is seen from the results that the fertility of the soil can be maintained when cropping in the native rotation, if every third year a crop of mucuna is grown and turned in; and that it is unnecessary to replace guinea corn with mucuna so as to get two crops of mucuna in three years. Unfortunately we have not worked control plots on the native system, so that we cannot say what are the diminishing returns when the native method is followed. The table below makes a comparison of the cropping of the two methods.

Native Rotation.	The Plantation Rotation.
Year—	*Year*—
1. Maize and Guinea corn.	1. Maize and Guinea corn.
2. Yams and cotton (cotton may or may not be grown).	2. Yams and cotton.
3. Maize and Guinea corn.	3. Mucuna.
4. Yams and cotton.	4. Maize and Guinea corn.
5. Maize and Guinea corn.	5. Yams and cotton.
6. Fallow.	6. Mucuna.
7. Fallow.	7. Maize and Guinea corn.
8. Fallow.	8. Yams and cotton.
9. Fallow.	9. Mucuna.
Fallow 4 years.	3 Mucuna crops.

New land may commence with either yams or maize and guinea corn. With the plantation rotation, in all probability, during the nine years, maximum crop returns will be obtained during six years, and three mucuna crops. The native rotation will give diminishing returns for five years, if the land is very good to start with, and these will be followed by, say four years' fallow. The difference in cost will be scarcely more than fourteen man days labour per acre with the plantation rotation for each year that the mucuna is grown, that is for the three mucuna years, forty-two man days. For these forty-two man days, spread over three years, the farmers will get six years full crops in place of five years diminishing crops.

A suggested method for the farmer to follow would be, to put one-third of each of his farms in mucuna each year, so that every three years all will have been once in mucuna.

COMPARATIVE OBSERVATIONS ON THE PESTS OF COTTON AT ILORIN, NORTHERN NIGERIA.

By

Owen B. Lean, b.sc., d.i.c., f.e.s.

Introduction.

During a number of past seasons surveys have been undertaken in the Oyo Province of Southern Nigeria to estimate the importance of the various factors inhibiting the production of good cotton. The failure of the cotton crops, more especially of the Allen variety, has been even more marked on the Ilorin Plantation of the Agricultural Department than in the experiments carried out further south and the investigations described in the present paper were planned to study the factors affecting the growth of the cotton in this locality and to compare these factors with those obtaining in the Oyo Province, emphasis being laid on the entomological aspects of the enquiry.

Although Ilorin is situated in the open savanna country the yearly rainfall does not differ greatly from that of Ibadan. The general character of the country is similar to that in which the surveys were undertaken in the season 1924-25 in the vicinity of Oyo.

It is to be noted that in the immediate vicinity of Ilorin, cotton is not grown in any quantity by the native farmers. This is probably due to the necessity of growing food stuffs in the vicinity of a large town. All native grown cotton is of the native (*peruvianum*) type and is grown in mixed cultivation. In 1922 the production of cotton in the Ilorin Province was reviewed by Thornton (6).

Methods Employed.

The following four varieties of cotton were studied—Allen, *G. hirsutum* (*var.* Allen's Long Staple), Ishan, *G. vitifolium*, Kabba, probably *G. vitifolium* and Ilorin, probably identical with ' Meko,' *G. peruvianum*.

The Allen was sown on July 15th, whilst all the native varieties studied in the present experiment were sown on July 1st, although plots sown at other dates existed on the farm. With the Allen the ridges were three feet apart and for the native varieties six feet apart; for all varieties there were two plants per stand and the stands were one and-a-half feet apart. The number of plants per acre on the plots on which the surveys were carried out were as follows:—Allen, 12,000 plants per acre; Ishan, 8,900; Kabba, 8,900; Ilorin, 8,300.

Plot Selection.—During the present season only half an acre of Allen cotton was sown and this plot was placed some distance from the main cotton experiments and since the cotton was grown on rather poor shallow soil which had been recovered from grass bush prior to the experiment the results obtained with the Allen cotton are hardly comparable with those obtained with the three native varieties, and emphasis will not be laid on the quantitative comparison. An one-eighth acre of this plot was selected for the detailed flower and shed counts, etc.

Two one-sixteenth acre plots of each of the three native cottons were selected for the flower and shed counts, etc., in two separate parts of ' B ' block where the principal cotton variety tests were being carried out on good soil. In both cases the one-sixteenth acre plots of the three varieties were adjacent, with the Ilorin between the Ishan and Kabba and these plots were placed in the middle of the two sections of ' B ' block in order to escape any edge effect. These two groups of one-sixteenth acre plots are referred to as Groups I and II. For all general considerations the mean of the results from the two plots of each of the native varieties has been taken, but since differences in the soil characters were shown to exist it has been found instructive to compare the individual plots in certain particulars. The reference numbers of the individual plots are shown in Table No. 2.

Stainer Index plots were selected on the Allen plot and on the native plots in one half of ' B ' block.

Over the greater part of the season *shedding* figures were obtained on two separated days per week by the usual method of clearing the plots of all sheds exactly twenty-four hours before the sheds were counted. These sheds were analysed according to the lesions, if any, found on the bud or boll shed and in cases where two or more types of lesions were present on the same shed the damage was divided equally between the factors concerned.

Flowers were also counted twice a week for the greater part of the season and in order that these figures might be accurate they were counted independently by two observers and the counts repeated if the results disagreed.

Mummied bolls, *i.e.*, immature bolls that dried up on the plant without shedding were removed from the plants each week.

Ripe bolls were harvested at fortnightly intervals and samples of each harvesting were analysed separately on the lock basis. Sampling was carried out by the following method: an assistant divided up the bolls into four well-defined classes, (1) apparently

undamaged bolls, (2) slightly damaged bolls, (3) severely damaged bolls, and (4) useless bolls. Samples of fifty from each class were examined, while if the total number of bolls in classes 2, 3 and 4 exceeded 200 the samples were increased to 100.

The *specific conductivities of soil extracts* from all plots were determined by Mr. C. H. Wright at the beginning and end of December.

The *stainer index* was carried out on plots of all varieties.

All *bollworms* found in sheds and open bolls were identified and the proportions of the species recorded.

Observations were kept on the other cotton plots on the farm as well as on an adjacent plot of native sown rama, *Hibiscus lunariifolius*. This crop which is sown in May apparently has an important bearing on the infestation of cotton by insects since nearly all the important pests were found feeding on this plant and it is grown on most farms during the interval between the cotton crops.

All figures, except those of the stainer index, are given per acre.

The Stainer Index.—The stainer index was carried out in the usual way on sample plots of the native cottons in the plots of Group II and on the Allen plot.

The migration of the stainers to the cotton and the relationships of the different types of *Dysdercus superstitiosus* were found to be similar to those found at Ibadan by Golding (1, etc.). In addition to this species, *D. ugandanus* and *D. fasciatus* occurred spasmodically and a very few specimens identified as *D. nigrofasciatus* were captured; the latter record appears to be the first definite notification of this species in Nigeria within recent years. No specimens of *D. melanoderes* were obtained.

It will be seen from Table I that the maximum initial migration to the Allen, Ishan and Ilorin cottons occurred during the week ending October 16th, while it was one week later to the Kabba. The Maximum migration was therefore two weeks before the maximum flowering of the Allen and Ilorin, five weeks before that of the Ishan and nine weeks before that of the Kabba. At the time of the maximum boll production on the Kabba there were practically no stainers left on the plots but the maximum boll production of the Ishan came shortly before the height of the second generation of stainers.

The small number of stainers on the Allen is probably entirely due to the small area of the plot. The difference in the numbers from the Ishan and Ilorin confirms the view that the stainers are not so attracted to the Ishan as to the other varieties; this is especially marked since the number of flowers produced by the Ishan was much greater than by the Ilorin. The Kabba escaped the stainer infestation because of its late flowering.

TABLE No. 1.

The Stainer Index.

Numbers of stainers per $\frac{1}{8}$th. acre.

Week ending.	Allen.		Ishan.		Kabba.		Ilorin.	
	Adults.	Nymphs.	Adults.	Nymphs.	Adults.	Nymphs.	Adults.	Nymphs.
Oct. 2 ...	0	0	27	0	10	0	42	0
„ 9 ...	54	0	117	0	103	0	102	0
„ 16 ...	170	0	926	0	134	0	1,074	0
„ 23 ...	40	18	482	424	140	0	345	973
„ 30 ...	14	97	123	574	74	112	106	241
Nov. 6 ..	2	114	72	1,311	47	276	110	3,312
„ 13 ...	1	65	33	1,322	24	339	73	1,182
„ 20 ...	0	27	15	349	7	205	31	625
„ 27 ...	13	24	32	161	28	115	110	1,180
Dec. 4 ...	29	1	225	78	48	22	456	636
„ 11 ...	3	149	249	72	42	13	306	93
„ 18 ...	2	239	91	27	6	1	105	118
„ 25 ...	1	135	60	338	6	4	58	74
Jan. 1 ...	3	44	25	321	5	4	14	103
„ 8 ...	20	93	8	143	3	5	8	33
„ 15 ...	18	22	2	21	0	2	8	17
„ 22 ...	12	3	—	—	...	...	...	...
„ 29 ...	3	5	—	—	...	...	...	...
Totals. ...	**385**	**1,036**	**2,487**	**5,141**	**667**	**1,108**	**2,948**	**8,587**

Bollworms.—The proportions of the different species of bollworm were determined from all specimens found on sheds and open bolls. The proportions were similar for all four cottons and remained fairly constant throughout the season. *Diparopsis castanea*, Hmps., was much the commonest bollworm, as many as 83.5 *per cent.* of all bollworms being of this species. Eleven *per cent.* were of the two species of *Earias*, *E. biplaga*, Walk. and *insulana*, Boisd., and 5.5 *per cent.* were *Argyroploce leucotreta*, Meyr. These percentages are derived from the analysis of 400 bollworms.

Specific Conductivities of Soil Extracts.

Mr. C. H. Wright has kindly placed the following results at the disposal of the author.

TABLE No. 2.

Group.	Plot.	Cotton variety.	Specific conductivity of 1-5 soil extracts at 0°C × 10°		
			Dec. 2nd.	Dec. 30th.	Mean.
I	B 13	Kabba	13	13	13
	B 14	Ilorin	15	17	16
	B 15	Ishan	14	13	14
II	B 34	Kabba	20	23	22
	B 35	Ilorin	21	27	24
	B 36	Ishan	17	19	18
...	...	Allen	15	13	14

It will be seen that the specific conductivities of the samples taken from the same plots do not differ greatly, except in the case of plot B 35. It is noticeable that the specific conductivities of plots B 34-36, in Group II, are greater than B 13-15 in Group I. This difference between the two groups was reflected in the behaviour of the plants as will be shown in later sections.

Bud Shedding.—As has been shown (Golding, Lean and Laycock, 2) it is impossible to obtain the total bud shedding figures by simple collection of the sheds and the total shedding percentages, calculated from the buds produced, given in Table 3 are presented to give some comparison between the cotton varieties.

The difference between the Allen and the native varieties corresponded closely with that obtained in previous comparisons and whereas there was no marked difference between the Ishan and Ilorin, the Kabba figure was significantly high. It was found that in the early part of the season the flowering of the Kabba cotton was retarded by the shedding of practically all buds that developed and the heavy shedding of these buds continued through October, November and the early part of December and did not cease until the last fall of rain.

Owing to the difficulty of diagnosing the causes of injury to small buds, the bud sheds were only classified into those damaged by bollworms, those undamaged and other buds. In this analysis the Allen showed the usual high percentage of bollworm damage.

Since the Kabba had the highest percentage undamaged and the lowest percentage damaged by bollworms, it is presumed that the high total shedding percentage was a physiological effect and it was noted that these buds showed a tendency to shed at a very early stage.

Considerable differences were found in the bud shedding of the two plots of each native variety as is shown in Table 3. It will be seen that all the plots in Group II showed much heavier shedding than those in Group I and since the difference between the percentages damaged in the two groups was not great it is presumed that the variations in the percentages of buds shed was correlated with the corresponding differences in the specific conductivities of the soil.

TABLE No. 3.

PLOT VARIATIONS IN BUD SHEDDING.

	Ishan.		Kabba.		Ilorin.	
	I	II	I	II	I	II
Total % shed ...	39	50	50	66	45	49
% damaged by boll-worms	12	9	5	6	9	6
% undamaged ...	66	67	80	75	65	75

Flower Production.—The total number of flowers produced are shown in Table 4. In general the flower production was exceptionally high and the figures for the Ishan and Ilorin cottons are some of the highest recorded in the course of the many surveys.

It was found that the Allen flower production was regular with the maximum production in week ending October 30th, this was followed by a steady decline until the end of November, following which came the usual small secondary flowering peak during week ending December 11th. The flower production of the Allen seemed to be unaffected by any undue shedding of buds or by any climatic conditions.

The flowering of the Ishan and Ilorin cottons were similar. In both cases the production rose to a high figure (the maximum for the Ilorin) at the end of October, during a dry period without rain; during the following two weeks when heavy rain fell the production of flowers was limited but rose again at the conclusion of the precipitation during week ending November 20th, the time of the maximum for the Ishan. After this the production fell nearly to zero in the middle of January and there had been no marked secondary rise by the time that flower counting was concluded on February 12th.

As has been pointed out above the flower production of the Kabba cotton was greatly delayed by the bud shedding. No flowers were produced until October 2nd, and from that date there was a gradual rise until the maximum production in week ending December 25th. There was a slight decrease of flowering in November as with the other native cottons, owing presumably to the rain that fell at this time. After the maximum production the flowering decreased rapidly but there was a small secondary rise at the end of January. The small total number of flowers produced by the Kabba cotton was very marked and most of these were formed at the top of the plants or at the apices of the upper fruiting branches. The first fruiting branches were formed at a very high node and all the vegetative branches below this node were normally void of leaves and bolls.

As is shown in Table 4 the flower production in the Ishan and Ilorin plots of Group II was greater than in Group I although a higher percentage of buds had been shed. With the Kabba, however, where the difference in the percentage of bud sheds was greatest the flower production in Group I was also the greater.

TABLE No. 4.

PLOT VARIATIONS IN FLOWER PRODUCTION.

	Group.	Ishan.	Kabba.	Ilorin.
Total No. ...	I	330,500	94,600	202,100
Flowers produced	II	358,800	89,500	235,000

It was also found that all the plots in Group II were one to two weeks behind those in Group I in the date of maximum flower production and that the flower production occurred over a longer period, owing, presumably, to the less rapid reduction of the soil moisture because of the shade thrown from the luxuriant foliage of the plants in Group II.

BOLL SHEDDING.

Since a full discussion of the actual causes of boll shedding is given in another paper, Golding, Lean and Laycock (2), this aspect of the question is not dealt with in the present paper as the shedding appeared to be normal and only the total shedding figures and the analysis of the lesions on the bolls are presented.

With the method of flower counting used the error in the flower estimates may be regarded as negligeable; the figures for mummied and harvested bolls may also be taken as accurate and the error, calculated at the end of the season when the total number of shed, mummied and harvested bolls added to the number remaining on the plants was compared with the total number of flowers produced, has been subtracted from the shedding totals. The errors in the shedding figures are shown in Table 5.

TABLE No. 5.

Calculated Error in the Total Shedding Figures.

	Allen.	Ishan.	Kabba.	Ilorin.
Flowers produced	193,800	344,700	92,100	218,500
Bolls shed	120,700	187,500	30,200	90,100
Bolls mummied	10,700	34,400	3,600	15,200
Bolls picked	67,600	128,900	58,600	128,600
Bolls remaining	1,600	11,500	0	0
Total bolls accounted for ...	200,600	362,300	92,400	233,900
Total shed error	— 6,800	— 17,600	— 300	— 15,400
% Shed error	— 5·6	— 9·4	— 1·0	— 17·1

The boll shedding totals for all varieties are similar to those found in previous surveys and the fluctuations need not be discussed in detail. At the time of a marked break in the rains at the end on October there was, however, a well-defined decrease in boll shedding for all varieties, the effect being also well marked with the bud shedding.

The differences between the plots in the two groups was similar for boll shedding as for bud shedding though more marked in the present case. For all three native varieties the plots in Group II exhibited heavier boll shedding than the plots in Group I. In all three cases the precentage of sheds with bollworm and bacterial lesions was greatest in Group I while a higher percentage of bolls bearing stainer lesions were shed in the plots of Group II. It seems likely that the heavy shade cast from the plants in Group II proved advantageous to the development of the stainer nymphs.

TABLE No. 6.

PLOT VARIATIONS IN BOLL SHEDDING.

	Ishan.		Kabba.		Ilorin.	
	I.	II.	I.	II.	I.	II.
Total % bolls shed	53	56	27	39	35	46
% Damaged by stainers	39	54	38	45	33	44
% „ „ bollworms ...	11	6	12	10	12	9
% „ „ bacteria	26	21	22	9	22	14
% Undamaged	21	15	18	28	26	27

MUMMIED BOLLS.

As will be seen from Table 7 no great percentage of bolls produced subsequently underwent mummification, the percentage being highest on the Ishan (ten *per cent.*). Only the percentages damaged by bollworms are given since these are the only lesions that can be identified with any certainty. Only a very small number of mummied bolls of the native cottons were attacked by *Anthracnose*. The chief difference between the plots in the two groups was that a higher percentage of bolls were mummied in Group I and that a higher percentage of the mummies were damaged by bollworms in this group as shown in Table 7.

TABLE No. 7.

PLOT VARIATIONS IN MUMMIED BOLLS.

	Ishan.		Kabba.		Ilorin.	
	I.	II.	I.	II.	I	II.
% Flowers mummied	11	9	5	3	8	6
% Mummies damaged by bollworms	19	11	29	23	27	12

HARVESTED BOLLS.

Allen Cotton.—As shown in Table 8 the extent of the damage to the picked bolls decreased from the commencement of harvesting until the middle of February and after this the crop suffered severe damage from bollworms. There was no great difference between the number of locks damaged by bollworms and by stainers and since locks damaged by bollworms are normally rendered useless while those damaged by stainers may only become stained it is probable that the bollworms were the most important factor. A higher percentage of locks were damaged by bollworms in the present experiment than in any of the surveys carried out in the Oyo Province, and since bollworms did not appear as numerous on the

cotton as in some past seasons it is probable that the bollworms have been the cause of the failure of the Allen crop in previous years.

As a result of their experiments during the season 1924-25, Mason and Wright (4) showed that a relationship existed between the specific conductivities of the soil extracts and the numbers of open bolls on the different plots, but in the present experiment the relationship was not found to be the same and the number of open bolls worked out at about twice the number calculated from the specific conductivities with the equation given.

TABLE No. 8.

ALLEN HARVESTED BOLLS.

Date of Picking.	No. of bolls.	% Boll Undamaged.	Lock Analysis.					Weight of seed cotton.		% Stained.
			% Undamaged.	% Useless.	% Damaged by:—					
					Bollworm	Stainer.	Bacteria.			
								lb.	oz.	
November 15th ...	3,960	0	0	99	58	44	0	0	4	100
„ 29th ...	9,600	8	15	48	40	38	5	25	12	48
December 6th ...	11,230	13	34	30	25	34	5	47	10	37
„ 24th ...	15,940	17	33	23	16	35	2	70	0	30
January 6th	10,880	24	40	23	17	42	0·3	52	6	23
„ 24th ...	4,280	30	42	21	19	35	0·1	20	4	15
February 7th... ...	6,980	39	58	13	25	7	0	34	12	13
„ 21st ...	3,610	26	37	30	46	4	0·6	13	6	20
March 7th ...	1,100	9	14	62	80	2	0	1	12	43
Totals ...	67,580	18	31	32	27	32	2	266	2	28

Native Varieties.—The same gradual decrease in the number of damaged locks and amount of stained seed cotton was found with all the native varieties, with a final rise at the close of the season due to the increased activity of the bollworms.

The Ilorin variety gave the highest yields but the lint was the most stained. The actual number of bolls harvested from the Ishan and Ilorin plots was almost identical, while the Kabba gave but little more than half this number. The low percentage of stained seed cotton for the Kabba was owing to the fact that with the delayed flowering the maximum harvesting practically coincided with the time of least damage to the bolls; the bolls picked at this time had matured after the heavy stainer infestation and before the bollworm damage had greatly increased.

It will be seen that except on the Kabba the stainer was the most important cause of damage. Bacterial disease caused but little damage to the Kabba and was of less importance than boll-worms on the other varieties. Damage by *Anthracnose* was negligeable. As in the Oyo Province the damage caused by the stainer was not so much the effect of the insect punctures as the result of infection of the bolls with internal boll disease, *Nematospora* sp., introduced by the stainers.

The variations between the plots in the two groups are shown in Table 10, and it will be seen that in the case of each variety the plot in Group II gave the higher yield and the lint was less stained since a lower percentage of locks were damaged. Bacterial damage was greater in Group I, as was the case with the boll shedding, but the damage caused by the remaining pathogens did not vary greatly from plot to plot.

Further variations were exhibited in the time of maximum bolling. Thus on the Ishan, for example, the greatest number of bolls were picked from the plot in Group I on January 17th, while the greatest number were not picked from the other group until February 14th.

TABLE No. 9.

Harvested Bolls, Native Varieties.

Ishan.

Date of picking.	No. of Bolls.	% Bolls undamaged.	LOCK ANALYSIS:—						Weight of seed cotton.	% Stained.
			% Undamaged.	% Useless.	% Damaged by:— Boll worm.	Stainer.	Bacterta.	*Anthrac-nose*		
									lb. oz.	
November 17th ...	2,380	0	1	91	15	41	42	0	1 0	75
„ 30th ...	3,620	3	11	60	18	20	47	2	6 4	52
December 13th ...	14,170	10	21	33	12	19	26	6	41 14	44
„ 30th ...	17,370	11	23	38	18	24	21	4	53 10	33
January 17th ...	29,170	26	40	20	11	33	10	2	124 12	19
„ 31st ...	27,740	44	57	12	9	23	4	0·8	133 6	10
February 14th ...	22,990	43	58	10	13	18	3	0·1	104 2	17
March 2nd ...	9,600	47	60	9	26	8	0·2	0·1	37 4	13
„ 14th ...	1,850	17	23	35	62	9	0·4	0·4	3 6	59
Totals ...	128,880	13	38	20	13	21	11	2	505 10	21

Kabba.

December 3rd ...	180	0	4	48	31	6	53	0	0 8	50
„ 21st ...	1,300	17	35	16	9	21	22	1	5 10	31
January 14th ...	4,420	20	37	21	13	37	12	0	20 2	20
„ 28th ...	9,250	33	46	13	13	35	3	0·3	43 8	13
February 11th ...	17,690	41	54	8	16	23	2	0	85 4	16
„ 25th ...	18,460	40	56	8	23	8	1	0·1	87 14	10
March 11th ...	7,260	35	47	18	38	6	0·2	0·7	22 10	25
Totals ...	58,550	36	51	11	25	19	3	0·2	265 8	15

Ilorin.

November 15th ...	3,390	0	0·1	96	13	84	21	0	0 8	100
December 3rd ...	7,730	1	4	59	12	42	29	0·5	15 0	72
„ 13th ...	13,520	7	14	25	8	33	23	3	52 2	64
„ 30th ...	17,470	8	19	27	11	27	20	0·9	57 12	53
January 17th ...	24,370	15	26	22	12	49	8	1·3	112 4	35
„ 31st ...	23,170	30	50	10	12	26	4	0·6	126 4	16
February 14th ...	23,770	38	55	10	18	20	2	0·2	121 6	19
March 1st ...	12,520	33	48	11	27	7	0·2	0	54 0	18
„ 14th ...	2,700	12	28	39	63	7	0	0·6	6 4	43
Totals ...	128,630	21	34	22	15	30	10	1	545 10	31

TABLE No. 10.

Plot Variations in Harvested Bolls.

	Ishan.		Kabba.		Ilorin.	
	I	II	I	II	I	II
Total bolls picked ...	119,500	138,300	55,300	61,800	122,000	135,300
% locks undamaged ...	36	48	44	56	30	36
% damaged by Bollworms	18	11	21	20	14	16
Stainers	20	25	22	16	30	31
Bacteria	15	9	4	2	12	8
Anthracnose ...	3	1	0·2	0·2	1	1
Total yield, lb. per acre ...	409	602	236	295	491	599
% lint stained	25	17	17	14	35	28

Miscellaneous Pests and Diseases.

Helopeltis spp. did not occur in any numbers. Individuals of the two species, *H. bergrothi*, Reut. and *H. sanguineus*, Popp., were observed and the adults seemed to show a preference for the Kabba cotton. In some past seasons this pest has been reported as being very numerous on the Ilorin Plantation.

Syagrus calcaratus, F. Adults of this beetle were numerous on the plants of all cotton varieties especially on the bolls late in the season. Damage by the rhyzophagous larvae was only observed on the Allen cotton and only a very low percentage of plants were severely attacked. Adults were common on the plants of rama.

Jassids were numerous on none of the plots on which surveys were carried out, but in one block (G) of Ishan cotton they were so abundant that the plants were dwarfed and malformed and all bolls formed in the early part of the bolling period were either shed or mummied. Later in the season the plants recovered slightly but the total yields were very small, and on no plot exceeded 50 lb. per acre. There was no marked difference in the intensity of the attack according to the different times of planting. It is presumed that this remarkable Jassid infestation was primarily due to the poor light soil of the plot and the consequent poor resistance of the plants. To quote Parnell (5), " there is no doubt that other things being equal . . . . . susceptibility to Jassid depends very largely on the condition of the plant. Speaking generally, a vigorous growth increases resistance, whereas any retardation of growth, to whatever cause it may be due, appears to increase susceptibility."

Aphids were only present in small numbers dispersed over the plants and never in large colonies. Coccinellids were abundant.

Leaf curl was of no importance though a few scattered plants were infected. This observation is of interest since in the past it has been presumed that either Jassids or Aphids are the probable vectors of this virus disease, but since Jassids were so numerous and curl very infrequent it is now necessary to exclude Jassids from the probable vectors while the case against Aphids is strengthened.

Leaf roll, although exhibited occasionally by plants of all varieties was of no economic importance.

Leaf crinkle (Mason and Wright, (3)), was exhibited by a great number of plants of the native varieties but probably had little effect on the ultimate yields.

A Summary of some of the Characters of the Kabba Variety of Cotton.

Since the present experiment is the first in which the Kabba cotton has been examined in any detail some of the peculiar characters of this cotton are outlined below.

Kabba was grown for the first time under plantation conditions at Ilorin in the season 1925-26. In that season the variety test in which the cotton was grown alone was carried out under the poor conditions that obtain in ' G ' block, where the Jassid attack was serious in the present season; under these conditions the Ilorin proved superior to the Kabba but both yields were very low. Grown through yams there was no significant difference between Ilorin and Kabba (7).

The plants are well able to withstand the onset of the arid conditions of December and January. In the latter month, when the leaves of the Allen plants had all shed and when those of the Ishan and Ilorin were brown and falling in quantities, the Kabba plants were most noticeable for the fresh appearance of the foliage.

The lint is of exceptionally good quality, long staple length, similar to that of the Ishan and is borne on a naked seed.

The bolls are large and from bolls picked throughout the season it was calculated that there were 146 average undamaged Kabba bolls to one pound of seed cotton as compared to 158 for the Ishan, 161 for the Ilorin and 126 for the Allen. The average loculus number worked out at 3.20, compared to 3.06 for the Ishan, 3.08 for the Ilorin and 3.94 for the Allen. Figures were obtained showing that those Kabba bolls that consisted of four locks did not suffer damage to the exent of those with only three: thus the average loculus number of undamaged Kabba bolls was determined at 3.19 as compared to 3.12 for damaged bolls in a number of samples. This divergence is due, presumably, to the fact that the greater the number of locks the less chance there is of infection by internal Boll Disease or the activities of bollworms to spread throughout the boll.

The most important feature of the Kabba cotton is, however, the late maturing. It has been clearly demonstrated in the present experiment how a late maturing cotton may escape the main stainer infestation.

General Summary and Conclusions.

1. Four varieties of July sown cotton have been studied, grown under plantation conditions at Ilorin.

2. Comparison of native cotton grown on soils with different specific conductivities have given the following results:—

(*a*) A higher percentage of buds and bolls were shed where the specific conductivity was high.

(*b*) In spite of the increased percentage of bud shedding, a greater number of flowers were produced where the specific conductivity was high.

(*c*) In spite of the increased percentage of boll shedding a greater number of bolls matured where the specific conductivity was high.

(*d*) As shown by analysis of bolls shed and harvested, bacterial disease caused more damage where the specific conductivity was low. Bollworms appeared also to cause more damage under these conditions, while the cotton stainers were more active where the specific conductivity was high, probably because more stainers were attracted to the plots where most flowers were produced and the shade cast by the more luxuriant foliage protected the nymphs.

(*e*) Where the specific conductivity was high the flowering and consequently the bolling was delayed causing a greater number of bolls to mature after the decrease of the stainer attack, so that the final yields were not only higher but the percentage of clean seed cotton was greater.

3. On all varieties the cotton stainer damaged the greatest number of locks, but on the Allen cotton at any rate bollworms probably caused more actual damage and it seems likely that in years when the crop has failed bollworms have been largely responsible.

4. Kabba cotton yielded a much smaller crop than either the Ishan or Ilorin, but this variety exhibited some characteristics that might make a selected strain of much value.

5. The difference in yield between the Ishan and Ilorin was small but the Ishan lint was the less stained and is of higher value.

In conclusion the author wishes to express his thanks to Mr. C. H. Wright for his assistance in supplying the specific conductivity determinations, to Mr. T. Thornton and Mr. W. B. Dowson for frequent help and advice, to Mr. F. D. Golding for assistance in the identification of stainers and to Mr. T. Laycock for the indentification of *Anthracnose* and *Nematospora* material.

TABLE No. 11.

		Allen.	Ishan.	Kabba.	Ilorin.
Bud sheds.	Total % shed	17	46	60	47
	% undamaged	55	67	77	73
	„ damaged by bollworms ...	43	10	6	8
Boll Sheds.	Total flowers produced ...	193,800	344,700	92,100	218,500
	Total bolls shed	113,900	169,900	29,900	74,700
	% shed	59	49	32	34
	„ damaged by bollworms ...	24	4	3	4
	„ damaged by stainers ...	22	23	13	14
	„ damaged by bacteria ...	0·2	12	4	6
	„ damaged by *Alternaria* ...	—	0·1	0·1	0·5
	, damaged by *Anthracnose*	--	0·01	--	0·03
	„ undamaged	12	9	8	9
Mummied Bolls.	Total no. of mummies ...	10,700	34,400	3,600	15,200
	% mummies	5	10	4	7
	„ damaged by bollworms ...	64	15	27	20
Harvested Bolls.	Total bolls havested ...	67,600	128,900	58,600	128,600
	% locks undamaged	31	42	51	34
	„ locks damaged by boll-worms	27	14	20	15
	% locks damaged by stainers	32	23	19	30
	„ locks damaged by bacteria	2	12	3	10
	„ locks damaged by *Anthrac-nose*	0	2	0·2	1
Seed Cotton.	Yield per acre, lb	266	506	265	546
	% seed cotton stained ...	28	21	15	31

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ANNUAL REPORT, MOOR PLANTATION, IBADAN, 1926.

The importance of our experimental work this year lies in the fact that this season has seen the completion of the first cycle of some of the rotation and fertility experiments laid down in 1923. The results from the main rotation blocks are promising; the groundnut crop this season constituted a record in high yields, the late maize crop was good, the cotton crop above average and only the early maize and yam crops were below average.

In the large " four-year rotation " blocks the yam crop was the only one which was worse than the crop on the same land in 1922, but that was considerably worse—about 8,000 lb. in 1926 as against 15,000 in 1922. There is reason to believe that this difference was not by any means entirely due to diminished natural fertility in the soil. Both in germination and in growth the yam crop is extremely sensitive to any adverse factor either in the weather or in the cultural treatment. We realise that as yet we do not understand fully the whole art of growing a maximum crop of yams. To study this matter, a large series of " minor " experiments were carried out in 1926 on small plots in one part of the same block which carried the main crop in both years. The results of those " minor " experiments were very instructive, and on the best small plots, yields comparable to those of 1922 were obtained.

It is generally agreed that the crops on Moor Plantation are much larger than those grown on local native farms, and as most of our land—which is typical of the district—has been under cultivation since 1912, there is reason to hope that we will be able soon to recommend better and more economical cultural methods to local farmers, who, as yet, have no conception of the possibilities of manuring in any of its forms, depending, as they do, on shifting cultivation to provide economical returns from farms which are rapidly exhausted by bad agricultural methods.

The results of three new experiments are included in this report, two of these experiments were designed to gather information on the treatment of cover crops, while the third is a test of fallow and perpetual cultivation in both stumped and unstumped land. Details of these experiments are given under the separate headings.

YAM EXPERIMENTS—1926.

Test of Furrows Dug *versus* Normal Planting Methods.

(*See* Table No. 2.)

This experiment is a repetition of a similar experiment conducted last year with the object of finding a substitute for "trenching" which had been proved to increase the yield of yams considerably but had the disadvantage of being expensive. In this year's experiment the furrows were dug to a depth of nine inches to twelve inches before the old ridges were split and the new ridges built upon the dug furrows. The results show an increase of approximately ten *per cent.* in yield on those plots where the furrows were dug but the odds in favour of the increase being significant are slight. The increased yield per acre of 737 lb. was made at a cost of 109 man days. If the market value of yams per pound is .43d. this is equivalent to an increase of £1 6s. 5d. per acre at a cost of £4 19s. 11d.

	Yields, lb. tubers per acre.	Germination %	Odds that difference is significant.
Average yield of 9 control plots without furrows dug in ...	7,551	74%	—
Average difference of 8 plots with furrows dug in ...	+716±787	78%	5 : 1

	Cost of crop in man days per acre.	Yield per acre in lb.	Cost of Production in man days per lb.	Market Value per lb.	Calculated return per acre.	Gross Monetary return per man day.
Furrows dug ...	362	8,288	·0436	·43d.	3,564d.	9·8d.
„ not dug	253	7,551	·0335	·54d.	3,247d.	12·4d.

Yams—Width of Ridges Experiment (*See* Table No. 3).

This test was carried out to confirm our previous experience that bigger yields of yams are obtainable from large ridges than from small ridges of three-and-a-half feet wide. The results of this experiment give very definite figures in favour of the larger ridges, *i.e.*, six feet.

	Yields, lb. tuber per acre.	Odds that difference is significant.
Average yield of 9 control plots planted on 6′ ridges	7,999	—
Average difference of 8 plots planted on 3½′ ridges	−2,569±276	Infinite.

YAMS—DEPTH OF PLANTING TEST (*See* TABLE NO. 4).

This test has again proved unsatisfactory and gives little information as to what is the optimum depth for planting yams. The variability of the results is almost certainly due to the fact that it is exceedingly difficult with local labour to plant accurately at set depths, while rains and after-cultivation cause the final " effective depths of planting " to become irregular. Moreover the germination of the seed was poor throughout the experiment. However, the results of the experiment would seem to indicate that the variations in depth of planting have not an extremely great effect on yield, since otherwise the effect would have shown up in spite of all these adverse influences.

	Yields lb. tubers per acre.	Germination %	Odds that difference is significant.
Average yield of 9 control plots planted 6" deep	8,160	55%	—
Average difference of 4 plots planted 3" deep	+720±960	57%	3 : 1
Average difference of 4 plots planted at 9" deep ...	+523±960	66%	2 : 1

YAMS—SIZE OF SET TEST (*See* TABLE NO. 5).

In the past it has been found that the best results are obtained from planting seed-yams and not cut tubers, but no information was available locally as to what was the optimum size of " seed " to plant. In certain districts of Nigeria it is said that the native farmers plant seed of approximately twenty-four ounces in weight, while in this district the usual weight is about eight ounces. The sets in this experiment were divided into " large," " medium " and " small," the respective average weights of which were 18.4 oz., 12.2 oz. and 8 oz.

The gross yields show a distinct and significant increase from the " large " sets as compared with " medium " sets, and a small decrease from the " small " sets, but if the nett yields under each treatment are examined the nett differences in yields are seen to be small; the extra weight originally put in is recovered in the final yield, but that is all.

	Yields, lb tubers per acre,	Germination %	Odds that difference is significant.
Average yield of 9 plots planted with "Medium" sets ...	6,334	67%	—
Average difference of 4 plots planted with "Small" sets	−412±818	67%	2 : 1
Average difference of 4 plots planted with "Large" sets	+2316±818	72%	390 : 1

NETT YIELDS.

	Medium sets.	Small sets.	Large Sets.
Nett yield, lb. tubers per acre...	3,148	3,797	3,748

GROUNDNUTS.

Size of Ridges Experiment (*See* Table No. 6).

Last year, when it was decided to put all our cultivated land on Moor Plantation into six feet ridges instead of three and-a-half feet ridges, it was thought that groundnuts would probably suffer from the change to larger ridges instead of benefitting as other annual crops were found to do. On account of this supposition a special experiment was carried out this year to test six feet ridges *versus* three feet ridges for groundnuts. The results are definitely in favour of the larger ridges, as the figures below show. The crop throughout was excellent.

	Yields, dry unshelled nuts lb. per acre.	Odds that difference is significant.
Average yield of 9 control plots planted on 6′ ridges	1,859	—
Average difference of 8 plots planted on 3′ ridges	−249±66	11,110 : 1

MAIZE—1926.

"Stand" Planting *versus* "Drilled" Seed (Early Maize). (*See* Table No. 8.)

The usual method of planting maize in this country is to dibble the seed into prepared holes at set intervals. It was suggested that for experimental purposes it would be desirable to drill in the seed, and the above experiment was designed to investigate the advantages and disadvantages of the two methods.

The results show a small decrease in yield from those plots on which the seed was drilled. This decrease although small is significant.

As regards labour there was little difference between the costs of the two methods. The drilled seed gave a more uniform germination, so that no "supplying" was necessary before thinning, whereas in the case of the stand planted plots considerable supplying was necessary and but little thinning.

	Yields, dry grain lb. per acre.	Odds that difference is significant.
Average yield of 10 plots "Stand" planted	2,080	—
Average difference of 9 plots with "drilled" seed	−98±46	55 : 1

Test of one plant at a stand at eighteen inches apart *versus* two at a stand at three feet (Early Maize).

(*See* Table No. 9.)

The native farmers grow several plants, at the very least two, at each stand, though the stands are often rather far apart. Previous experiments have shown that on normal good land, within any reasonable limit, the more plants the more the yield, however the plants are arranged. But, the number of plants being equal, plants growing singly should give the larger yield. On the other hand, if cotton has to be interplanted with early maize, as in local farming practice, it is of great advantage to have the stands of maize at least three feet apart. The above experiment was carried out in order to find out what extent, if at all, the yield was reduced when maize was planted two at a stand as compared with maize planted one at a stand, but with the stands at half the distance apart. No significant difference is to be observed between the methods in this experiment.

	Yields, dry grain lb. per acre.	Odds that difference is significant.
Average yield from 10 plots planted one at a stand 18″ apart	1,884	—
Average difference of 9 plots planted two at a stand 3′ apart	−56±77	3 : 1

Test of One Plant to a Stand at 18″ *versus* Two at a Stand at (Late Maize) Three Feet. *See* Table No. 10.

In this experiment owing to the attacks of " army worm " a great number of the stands contained only one plant where there should have been two, while a considerable fraction of the single stands were destroyed. In spite of this the yields were very good and single stand plots gave the heavier crop. The faults in the experiment tended to reduce this superiority, so that, although a definite conclusion is not justifiably drawn from such unsatisfactory experiment, this trial tends to indicate that the single stand is definitely superior for late maize.

	Yield of dry grain, lb. per acre.	Odds that difference is significant.
Average yield from 20 plots planted one at a stand at 18 inches apart ...	1,247	—
Average difference from 18 plots planted two at stand at 3 feet apart ...	− 124 ± 48	213 : 1

GREEN MANURE EXPERIMENT—1926 (TABLE NO. 11.)

	Yield lb. per acre.	Odds that difference is significant.
Average yield of 7 plots of cotton following Mucuna	359	—
Average difference of 2 plots of cotton following Dolichos	+ 1 ± 32	—
Average difference of 2 plots of cotton following Canavalia	+ 9 ± 32	—
Average difference of 2 plots of cotton following Cowpeas	+ 50 ± 32	17 : 1

In this experiment the various green manures are sown in the early part of each season, about March each year. In July these are dug in and followed immediately by a " testing crop." The testing crop is late maize or cotton in alternate years.

The crop grown in 1926, the fourth year of the experiment, was unselected Ishan cotton. Although the yield was greater than in 1924, when the last crop was grown on this block, this may well have been due to the season, which for cotton has been more favourable than usual, and not to the continued green manuring. However, there is, at all events, no evidence of decreased fertility.

COVER CROP EXPERIMENT—1926 (*See* TABLE NO. 12).

This experiment resembles that just described except that the treatment of the field is varied in the latter part of each season and the testing crop, maize every year, follows in the early part of the next season. This experiment is situated on a part of the farm where all the land is very poor, and through various mischances it has happened year after year that the cover crops have not been very good. However, in spite of all this, the yield of maize this season on the control plots was as high as that given by these plots two seasons ago when the experiment was started. The experiment has not been continued long enough to justify any definite conclusions beyond the fact that a cover crop is better than weeds. The difference between the various plots this year are similar to those of the two previous years, excepting that the increase in yield, from the plot of Dolichos dug in each year on December 1st, is less than in previous years, and is of no significance. It is noticeable that those plots where cowpeas have been grown for three years in succession are now apparently " cowpea sick," as the plants in reaching a certain stage in growth make no further progress and die back, although no symptoms are to be found of any specific disease. The control plots of Dolichos all suffered from the attacks of *sclerotium rolfsii*, in fact the Dolichos all over the farm has suffered in the same way to such an extent that its general use will be discontinued in favour of Mucuna which remains healthy.

	Yields dry grain lb. per acre.	Odds that difference is significant.
Average yield of 11 plots following Dolichos	1,243	—
Average difference of 2 plots following Canavalia	−171±213	4 : 1
Average difference of 2 plots following Mucuna	−111±213	2 : 1
Average difference of 2 plots following Cowpeas	−145±213	3 : 1
Average difference of 1 plot following Dolichos dug in on Dec. 1st ...	+ 54±301	—
Average difference of 1 plot following Weeds (not cultivated)	−516±301	21 : 1
Average difference of 1 plot following Weeds (cultivated Dec. 1st & Jan. 1st)	−311±301	6 : 1

Manurial Experiment—1926.

Early Cropping A3N. Maize (Table No. 13.)

The block (A3) used for the manurial experiment, which was started in 1923, is divided into two parts. Of these the northern part is exhaustively cropped while the southern part has two leguminous crops dug in in every three years thus :—

Northern portion—A3N.—1923 and 1926, maize and cotton; 1924, maize and maize; 1925, yams and maize.

Southern portion—A3S.—1923 and 1926, green manure and cotton; 1924, maize and maize; 1925, yams and cover crops.

Although the field slopes towards the south there was no great difference in 1921, when both parts were in a fair state of fertility. The difference now is very marked, and the northern portion now yields very poor crops. Manures are applied each year to both portions so as to test the effects of the manures under two very different sets of conditions :—

	Yield of dry grain, lb per acre.	Odds that difference is significant.
Average yield of 7 control plots not manured	482	
Average difference of 2 plots manured at rate of 13 cwt. cotton seed per acre	+ 40±152	—
Average difference of 2 plots manured at rate of 10 cwt. locally ground phosphate per acre	− 82±152	2 : 1
Average difference of 2 plots manured with cotton-seed & phosphate at above rates	− 12±152	—

The phosphate and cotton-seed manures are applied to the appropriate plots each year.

Manurial Experiment—Late Cropping (Table No. 14).

In previous years the local phosphate rock applied each year has been ground and powdered as finely as possible by pounding, but this year ten tons of granular phosphate rock, from Ifo district of Abeokuta Province, were sent to England to be finely ground. This finely ground phosphatic rock was applied for the first time this year at the time of planting the cotton crop on the experimental areas, both north and south. The results of the cotton crop this year show no definite results as regards the effect of the manuring with cotton seed and phosphate.

	Yield cotton in lb. per acre.	Odds that difference is significant.
A. 3 N.		
Average yield 7 plots unmanured ...	204	
Average difference 2 plots manured with cotton seed	+16±21	—
Average difference 2 plots manured with rock phosphate	− 7±21	—
Average difference 2 plots manured with both cotton seed and rock phosphate	− 1±21	—
R=30.		
A. 3 S.		
Average yield of 7 unmanured plots ...	407	
Average difference of 2 plots manured with cotton seed	−70±72	—
Average difference of 2 plots manured with rock phosphate	− 5±72	—
Average difference of 2 plots manured with both cotton seed and phosphate	+17±72	—
R=102.		

Grass Fallowing Experiment—1926 (Tables No. 15 and 16).

This experiment was commenced in 1922 to test weed or grass fallows of two or three years against green manuring in rotation. The first series finished in 1925, and the present cropping was intended to exhaust the land thoroughly before starting a new series of fallowing tests, and also to confirm the results of the first series. The testing crop of yams in 1925 showed an increase in yield on those plots which had been cultivated continuously, whereas a maize crop following the yams, in the same year, in the northern half of the field only, showed a slight increase of no significance on those plots which had been fallowed. Since that time two maize crops have been taken off the whole area. These two maize crops give definite results in favour of those plots which were fallowed for various periods between 1922 and 1925.

Thus it appears that at the end of the experimental period the rotation plots were in better condition than the bush fallowed plots, but the latter possessed a greater "reserve of fertility" which enabled it to yield better in the continued very exhaustive "testing cropping."

Early Cropping Z2. 1926.—Maize (Table No. XV).

	Yield of dry grain, lb. per acre.	Odds that difference is significant.
Average yield of 10 plots, cultivated continuously from 1922 to 1925	1,055	—
Average difference of 2 plots, after 2 years' fallow and woody weeds removed yearly from 1922 to 1925	+ 72±173	—
Average difference of 2 plots, after 3 years' fallow and woody weeds removed yearly from 1922 to 1925	+288±173	21 : 1
Average difference of 2 plots, after 3 years' fallow and woody weeds left from 1922 to 1925	+255±173	13 : 1
Average difference of 2 plots, after 3 years' fallow and bush burnt yearly from 1922 to 1925	+130±173	3 : 1
Average difference of 8 plots, after 2 or 3 years' fallow from 1922 to 1925 ...	+186±87	55 : 1

Late Cropping Z2n. 1926.—Maize. (Table No. XVI).

	Yield of dry grain, lb. per acre.	Odds that difference is significant.
Average yield of 5 plots, cultivated continuously from 1922 to 1925	638	—
Average difference of 1 plot, bush and woody weeds removed yearly from 1922 to 1925	+143±72	43 : 1
Average difference of 1 plot, 3 years' bush and woody weeds removed yearly from 1922 to 1925	+132±72	27 : 1
Average difference of 1 plot, 3 years' bush and woody weeds left from 1922 to 1925	+244±72	3,029 : 1
Average difference of 1 plot, 3 years' bush and bush burnt yearly from 1922 to 1925	+250±72	4,350 : 1
Average difference of 4 fallow plots of 2 or 3 years' fallow from 1922 to 1925	+192±36	Infinite.

Treatment of Cover Crop Experiment—1926 (Table No. 17).

This is a new experiment commenced in 1925 and was designed to give information on the treatment of cover crops. Its immediate objects are:—

(1) To test the effect of re-ridging ground at the end of the dry season, as against moulding up the old ridges only, as a method of preparatory cultivation, or, by continuing the experiment for some years to ascertain how often thorough cultivation ("ridging") is necessary.

(2) To test the effect of digging in a cover crop green, as against the method of allowing it to rot on the surface before digging it under.

In the literature of the subject, it seems often to be assumed that green manures must be dug in while in a very fresh condition and drying even a day or two is apparently regarded as disadvantageous. To test this idea the leguminous crop in four plots was allowed to dry for the whole dry season before being dug in.

	Yields, dry grain, lb. per acre.
Average yield of 5 plots, cover crop burnt in March and then dug in	2,098
Average difference of 4 plots, cover crop burnt in March and then moulded up	+30±130
Average yield of 5 plots, cover crop cut in November and dug in at once	2,269
Average difference of 4 plots, cover crop cut in November and dug in in March	−22±122

The cover crop of mucuna was heavy and uniform, and the yield of maize throughout the experiment was satisfactory, but no significant difference between the different treatments is to be seen yet. The experiment will be continued.

(*Note.*—This experimental block of five acres has been in cultivation since 1912 with the exception of four years and the control plots this year showed an increase of thirteen *per cent.* in yield over the average for all plots on the area for the year 1924 when maize was last grown. Seven leguminous crops have been grown since 1912 and one since 1924. Exhaustive crops taken off the area since 1912 amount to ten.)

Dry Season Treatment of Cover Crop Experiment—1926.

(Table No. 18.)

This experiment like the foregoing one (Table No. 17) is designed to test methods of managing leguminous cover crops. In this one the object is to test the effect of allowing the leguminous crop to stand and mature throughout the dry season before digging it under in March or the end of the dry season. This is the first year of the experiment. The cover crop was mucuna and the testing crop early maize.

	Yields, dry grain lb. per acre	Odds that difference is significant.
Average yield of 9 control plots dug in at the begining of the dry season (Nov.)	2,308	—
Average difference of 8 plots, dug in at the end of the dry season (March) ...	−102±90	7 : 1

The cover crop throughout was heavy and the maize crop good but the difference in yields between the two treatments is small and of no significance. Several years must elapse before the cumulative effect of the treatments becomes apparent. As regards the advantages to be obtained from either treatment, from the farming standpoint it is a great convenience to dig in the cover crop at the beginning of the dry season, while the ground is still reasonably soft and the cover crop succulent and manageable; moreover it is thus removed from the danger of fire. But the effect of leaving the soil bare and loose throughout the dry season after the digging in process is unknown; and moreover where the cover crop is left throughout the dry season, there must be some increase in " dry matter " in the cover crop over and above its dry matter content in November, because a certain amount of growth goes on even at this season.

Stumping Experiment—1926 (Table No. 19).

This experiment was begun this season with the object of testing the effect of bush fallows of four years duration against perpetual cultivation in both stumped and unstumped land. The cropping this year was early maize on all plots, followed by mucuna cover crop on the rotation plots, Next season the control plots will be allowed to go into bush again while a reasonable rotation is to be followed on the " treated " plots. After four years, a testing crop will be taken off all the plots.

	Yields, dry grain lb. per acre.	Odds that difference is significant.
Average yield of 9 controlled plots not stumped	2123	—
Average difference of 4 stumped plots (to be rotated)	+11±79	—
Average difference of 4 unstumped plots (to be rotated)	−124±79	17 : 1

The difference between the four unstumped plots which are to be under rotation and the controls is inexplicable, except by chance; it will be noted that it is not quite large enough to be regarded as " significant " by our standards. The fact that the stumped plots did not show any increase was unexpected; but results in later years will be more important. Near Ibadan native fields are generally partially stumped. In some parts of the Southern Provinces they are not stumped at all. This year's results show that the field is fairly uniform, and they will be important for comparisons when a testing crop is grown again in four years' time.

THREE YEAR ROTATION EXPERIMENT.

This experiment was discontinued this year as it was yielding no useful results. No discernable difference was found between the different treatments.

FOUR YEAR ROTATION EXPERIMENT.

(Table No. 20.)

This experiment was begun in 1923 to test the effect of varying the frequency of green manuring. The results this year after the first rotation of four years are not definitely in favour of any particular frequency. The experiment is to be continued for a further period. Selected Ishan cotton planted on YB this year gave a yield above the average for the farm.

COTTON, 1926-27.

Ishan and Meko Planted Through Yams. (Table No. 21.)

The yields of both unselected Ishan and Meko were slightly above the average yield for the farm this year. The unselected Ishan cotton gave a slight, barely significant, increase as compared with the unselected Meko. This result is interesting because the cotton was grown as the local farmers usually grow it, *viz.*, through yams. It is from the ordinary Ishan that pure strains of selected Ishan have been bred which will, it is hoped, eventually replace the Meko cotton, which is now grown in this neighbourhood and in the provinces of Ilorin, Oyo and Abeokuta.

	Seed cotton lb. per acre.	Odds that difference is significant.
Average yield of 9 plots, Meko	574	—
„ difference of 8 plots, Ishan ...	+ 53±28	34 : 1

COCOA—1926.

(Table No. 22.)

The two and-a-half acres of yellow pod cocoa in A1 yielded at the rate of five and-a-half hundredweights dry beans per acre.

A test was carried out to find the loss in dry weight incurred through fermenting; this loss being found to be four *per cent.* (*see* Table 23A).

PALM WINE—1926.

(Table No. 23.)

Of the original ten trees in this experiment started in 1917 only four bore male inflorescences which could be tapped in 1926. The two best trees have yielded 108 and 109 gallons respectively since 1917.

KOLA—1926.

(Table No. 24.)

The yield from the two and-a-half acres of Gbanja kola, planted in 1913, was 466 lb. of fresh nuts per acre as compared with 349 lb. per acre in 1925.

COFFEE—1926.

(Table No. 25.)

The yield this year has again been very poor, as it was in 1925. The highest yield recorded was 604 lb. per acre in 1924.

COCONUTS—1926.

(Table No. 26.)

The yield from the ten acres of coconuts was less than in the previous year but the percentage of bad nuts has decreased.

OIL PALM YIELDS—1926.

(Table No. 27.)

DISTRIBUTION OF PLANTS.

The following were distributed from the nursery during the year:—140 coconut palms, 564 kola plants, 2,568 fruit trees, 3,474 ornamental plants and 142 various economic plants.

POULTRY.

The only breed now kept at Moor Plantation is Rhode Island Red; 575 eggs for hatching were distributed during the season.

A. GLENDON HILL,

Superintendent.

TABLE No. 1.

Rainfall 1926.

Moor Plantation, Ibadan.

Month.	Rainfall in inches.	Average rainfall for a period of seventeen years from 1910-1926.
January	0·30	0·21
February	1·23	0·81
March	3·30	3·58
April	5·71	6·12
May	6·96	5·98
June	8·78	7·35
July	3·13	6·25
August	2·72	3·57
September	13·73	7·39
October	5·53	6·40
November	1·71	2·09
December	0·16	0·15
Total	53·26	49·90 inches.

TABLE No. 2.

YAMS—TEST OF FURROWS DUG *versus* FURROWS NOT DUG.

Plot.	Treatment.	Yield of tubers lbs. per acre.		Increase (+) or decrease (−) compared with mean of adjacent controls.
Z7S.21	Furrows not dug	9,268		
22	,, dug		8,800	−1,037
23	Furrows not dug	10,406		
24	,, dug		12,746	+2,645
25	Furrows not dug	9,796		
26	,, dug		9,812	+1,497
27	Furrows not dug	6,834		
28	,, dug		7,424	+ 318
29	Furrows not dug	7,378		
30	,, dug		7,364	+1,010
31	Furrows not dug	5,330		
32	,, dug		6,286	− 669
33	Furrows not dug	8,580		
34	,, dug		6,832	+ 107
35	Furrows not dug	4,870		
36	,, dug		7,044	+1,859
37	Furrows not dug	5,500		
	Average	7,551		+ 716

"R"=2,226 lbs. per acre.

Average yield of 9 control plots with furrows not dug 7,551 lbs. per acre.

,, difference 8 plots with furrows dug ... +716±787.

Yams planted January 5th, 1926. Harvested December 3rd, 1926.

Each plots = $\frac{1}{4}$ acre.

TABLE No. 3.

YAMS—WIDTH OF RIDGES TEST.

No. of Plot.	Width of Ridges.	Yields of tubers lbs. per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
Z7N. Plot 1	6′	9,120	
2	3½′	6,344	− 2,428
3	6′	8,424	
4	3½′	4,564	− 3,914
5	6′	8,532	
6	3½′	5,860	− 2,740
7	6′	8,668	
8	3½′	5,920	− 2,311
9	6′	7,794	
10	3½′	5,250	− 2,520
11	6′	7,746	
12	3½′	5,520	− 1,965
13	6′	7,224	
14	3½′	4,592	− 2,232
15	6′	6,424	
16	3½′	4,796	− 2,445
17	6′	8,058	
	Average ...	7,999	− 2,569

R = 780.

Average yield of 9 control plots planted on 6′ ridges 7,999 lbs. per acre.
„ difference 8 plots planted on 3½′ ridges ... −2,569 ± 276.

Yams planted January 15th, 1926. Harvested January 13th, 1927.
Each plot = ¼ acre.

TABLE No. 4.

YAMS—DEPTH PLANTING TEST.

Plot.	Depth of Planting.	Yield of tubers lb. per acre.		Increase (+) or decrease (−) compared with mean of adjacent controls.	
A7S.	″				
Plot 24	6	9,436			
25	3		9,306	+ 772	
26	6	7,632			
27	9		7,842		− 10
28	6	8,072			
29	3		7,488	+ 188	
30	6	6,528			
31	9		9,010		+ 967
32	6	9,558			
33	3		10,814	+ 969	
34	6	10,132			
35	9		8,238		− 1,910
36	6	10,164			
37	3		9,400	+ 952	
38	6	6,732			
39	9		9,006		+ 3,047
40	6	5,186			
	Average ...	8,160		+ 720	+ 523

R = 1,921 lb. per acre.

Average yield of nine control plots planted at 6″ deep 8,160 lb. per acre.

„ difference of four plots planted at 3″ deep + 720 ± 960.

„ „ four „ „ „ 9″ „ + 523 ± 960.

Yams planted 20th January, 1926. Harvested 29th November, 1926,

Each plot = $\frac{1}{4}$ acre.

TABLE No. 5.

YAMS—SIZE OF SET TEST.

Plot.	Size of Set.	Yield of tubers lb. per acre.		Increase (+) or decrease (−) compared with mean of adjacent controls.	
A7N.					
Plot 4	Medium	7,142			
5	Small		5,192	− 1,373	
6	Medium	5,988			
7	Large		9,128		+ 2,718
8	Medium	6,832			
9	Small		5,964	− 1,555	
10	Medium	8,206			
11	Large		11,270		+ 4,692
12	Medium	4,950			
13	Small		6,176	+ 1,422	
14	Medium	4,558			
15	Large		6,758		+ 976
16	Medium	7,006			
17	Small		6,428	− 143	
18	Medium	6,136			
19	Large		7,040		+ 877
20	Medium	6,190			
	Average	6,334		− 412	+ 2,316

R = 1,637.

Average yield of nine control plots planted with medium sets 6,334 lb. per acre.

„ difference of four plots planted with small sets − 412 ± 818.

„ „ four „ „ „ large „ + 2,316 ± 818.

Yams planted 20th January, 1926. Harvested 23rd December, 1926.

Each plot = ¼ acre.

TABLE No. 6.

GROUNDNUTS, 1926.

Size of ridges test. B4W. 5 acres

This crop was harvested in $\frac{1}{8}$ acre plots.

Plot.	Size of Ridges.	Yield of dry unshelled Nuts.			Increase (+) or decrease (−) compared with mean of adjacent controls.
		Per plot.		Per acre.	
B4W.					
1A	Non-expt.	202, 230 } 432			
1B	,,				
2A	,,	205, 157 } 362			
2B	,,				
	feet				
3A	6	201, 214 } 415	1,660		
3B	6				
4A	3	205, 157 } 362		1,448	− 378
4B	3				
5A	6	259, 239 } 498	1,992		
5B	6				
6A	3	202, 184 } 386		1,544	− 444
6B	3				
7A	6	245, 251 } 496	1,984		
7B	6				
8A	3	206, 185 } 391		1,564	− 348
8B	3				
9A	6	230, 230 } 460	1,840		
9B	6				
10A	3	188, 215 } 403		1,612	− 132
10B	3				
11A	6	196, 216 } 412	1,648		
11B	6				
12A	3	167, 221 } 388		1,552	− 254
12B	3				
13A	6	224, 267 } 491	1,964		
13B	6				
14A	3	187, 239 } 426		1,704	− 248
14B	3				
15A	6	219, 266 } 485	1,940		
15B	6				
16A	3	192, 258 } 450		1,800	− 90
16B	3				
17A	6	203, 257 } 460	1,840		
17B	6				
18A	3	179, 258 } 437		1,748	− 102
18B	3				
19A	6	179, 286 } 465	1,860		
19B	6				
20A	Non-expt.	132, 254 } 386			
20B	,,				
		Average 1,859			− 249 ± 66

Average yield of plots in 6′ ridges 1.859 lb. per acre
,, difference of plots in 3′ ridges − 249 ± 66.
R = 187.

Groundnuts planted 18th March, 1926,
,, harvested 20th August, 1926.

TABLE No. 7.

GROUNDNUTS, 1926.

A6S. *Non-experimental. Harvested in $\frac{1}{8}$ acre plots.*

Plot.		Yield per $\frac{1}{8}$ acre plot.	Yield ("A" "B").	Yield per acre ("A" and "B").
A6S.	1 A	212	408	1,632
	1 B	196		
	2 A	186	410	1,640
	2 B	224		
	3 A	186	359	1,436
	3 B	173		
	4 A	166	355	1,420
	4 B	189		
	5 A	199	360	1,440
	5 B	161		
	6 A	165	353	1,412
	6 B	188		
	7 A	202	369	1,476
	7 B	167		
	8 A	173	374	1,496
	8 B	201		
	9 A	160	334	1,336
	9 B	174		
	10 A	165	356	1,424
	10 B	191		
	11 A	177	475	1,500
	11 B	198		
	12 A	169	359	1,436
	12 B	190		
	13 A	189	399	1,596
	13 B	210		
	14 A	176	351	1,404
	14 B	175		
	15 A	205	346	1,384
	15 B	141		
	16 A	155	322	1,288
	16 B	167		
	17 A	168	357	1,428
	17 B	189		
	18 A	162	317	1,268
	18 B	155		
	19 A	162	330	1,320
	19 B	168		
	20 A	139	297	1,588
	20 B	158		

Average ... ... 1,446 lb. per acre.

Planted 7th April, 1926. Harvested 18th August, 1926.

TABLE No. 8.

Early Maize, 1926.

Stand Planted *versus* Drilled Seed.

D5N. 5 acres.

Plot.	Treatment.	Yields lb. per dry grain		Increase (+) or decrease (−) compared with mean of adjacent controls.
		Controls.	Treatment.	
D5N 1	Stand planted	1,940		
2	Drilled		1,724	− 234
3	Stand planted	1,976		
4	Drilled		2,068	+ 24
5	Stand planted	2,112		
6	Drilled		2,068	− 78
7	Stand planted	2,180		
8	Drilled		2,088	− 122
9	Stand planted	2,240		
10	Drilled		2,196	− 74
11	Stand planted	2,300		
12	Drilled		2,108	− 34
13	Stand planted	1,984		
14	Drilled		2,032	+ 72
15	Stand planted	1,936		
16	Drilled		1,980	− 44
17	Stand planted	2,112		
18	Drilled		1,668	− 396
19	Stand planted	2,016		
20	Drilled		(1,580)	
	Average ...	2,080		− 98 ± 46

Average yield 10 plots "Stand planted" 2,080 lb. per acre.

„ difference 9 plots "Drilled" − 98 ± 46.

R = 139.

Maize planted 22nd April, 1926.

„ harvested 11th August, 1926.

TABLE No. 9.

EARLY MAIZE, 1926.

ONE PLANT AT 18″ *versus* 2 AT 3′

Harvested in $\frac{1}{8}$ *acres.*

Plot.		Treatment.	Yield per $\frac{1}{8}$ acre plot.	Yield per acre "A" and "B" x4.	Increase (+) or decrease (−) compared with mean of adjacent controls
D68	21 A	1 plant at 18″	234	1,880	
	21 B	ditto	236		
	22 A	2 plants at 3′ ...	252	1,928	− 14
	22 B	ditto	230		
	23 A	1 plant at 18″ ...	275	2,004	
	23 B	ditto	226		
	24 A	2 plants at 3′ ...	222	1,752	− 322
	24 B	ditto	216		
	25 A	1 plant at 18″ ...	265	2,144	
	25 B	ditto	271		
	26 A	2 plants at 3′ ...	260	2,088	+ 50
	26 B	ditto	262		
	27 A	1 plant at 18″ ...	225	1,932	
	27 B	ditto	258		
	28 A	2 plants at 3′ ...	217	1,780	− 106
	28 B	ditto	228		
	29 A	1 plant at 18″ ...	202	1,840	
	29 B	ditto	258		
	30 A	2 plants at 3′ ...	215	1,808	− 82
	30 B	ditto	237		
	31 A	1 plant at 18″ ...	221	1,940	
	31 B	ditto	264		
	32 A	2 plants at 3′ ...	218	1,852	+ 136
	32 B	ditto	245		
	33 A	1 plant at 18″ ...	185	1,492	
	33 B	ditto	188		
	34 A	2 plants at 3′ ...	228	1,900	+ 366
	34 B	ditto	217		
	35 A	1 plant at 18″ ...	170	1,576	
	35 B	ditto	225		
	36 A	2 plants at 3′ ...	167	1,580	− 198
	36 B	ditto	228		
	37 A	1 plant at 18″ ...	230	1,980	
	37 B	ditto	265		
	38 A	2 plants at 3′ ...	198	1,684	− 334
	38 B	ditto	223		
	39 A	1 plant at 18″ ...	248	2,056	
	39 B	ditto	266		
	40 A	2 plants at 3′ ...	211	(1,712)	
	40 B	ditto	217		
		Average		1,884	− 56 ± 77

R = 230.

Average yield of plots spaced 1 plant at 18″ = 1,884 lb. per acre.
" difference of plots spaced 2 plant at 3′ − 56 ± 77.
Maize planted 21st April, 1926.
" harvested 11th August, 1926.

TABLE No. 10.

Late Maize—Test of one Plant at a Stand *versus* two at a Stand.

Plot.	No. of plants at a stand.	Yield of dry grain lb. per acre.		Increase (+) or decrease (−) compared with mean of adjacent controls.
A5 1	1 at a stand 18″ apart ...	1,428		
2	2 „ 3′ „ ...		1,308	− 66
3	1 „ 18″ „ ...	1,320		
4	2 „ 3′ „ ...		1,236	− 208
5	1 „ 18″ „ ...	1,568		
6	2 „ 3′ „ ...		1,044	− 418
7	1 „ 18″ „ ...	1,356		
8	2 „ 3′ „ ...		1,168	− 332
9	1 „ 18″ „ ...	1,644		
10	2 „ 3′ „ ...		1,120	− 306
11	1 „ 18′ „ ...	1,208		
12	2 „ 3′ „ ...		1,176	− 142
13	1 „ 18″ „ ...	1,428		
14	2 „ 3′ „ ...		1,212	− 182
15	1 „ 18″ „ ...	1,360		
16	2 „ 3′ „ ...		1,328	− 78
17	1 „ 18″ „ ...	1,452		
18	2 „ 3′ „ ...		1,472	− 122
19	1 „ 18″ „ ...	1,736		
20	2 „ 3′ „ ...		(1,516)	
21	1 „ 18″ „ ...	1,360		
22	2 „ 3′ „ ...		1,160	+ 2
23	1 „ 18″ „ ...	956		
24	2 „ 3′ „ ...		980	− 28
25	1 „ 18″ „ ...	1,060		
26	2 „ 3′ „ ...		1,080	+ 16
27	1 „ 18″ „ ...	1,068		
28	2 „ 3′ „ ...		1,004	− 46
29	1 „ 18″ „ ...	1,032		
30	2 „ 3′ „ ...		888	− 86
31	1 „ 18″ „ ...	916		
32	2 „ 3′ „ ...		888	− 54
33	1 „ 18″ „ ...	968		
34	2 „ 3′ „ ...		864	− 116
35	1 „ 18″ „ ...	992		
36	2 „ 3′ „ ...		948	− 44
37	1 „ 18″ „ ...	992		
38	2 „ 3′ „ ...		1,012	− 34
39	1 „ 18″ „ ...	1,100		
40	2 „ 3′ „ ...		(1,320)	
	Average	1,247		− 124

R=202 lbs. per acre.

Average yield of 20 plots planted 1 at a stand 18′ apart ... ... 1,247 lbs. per acre.

Average difference of 18 plots planted 2 at a stand 3′ apart ... ... − 124 + 48

Maize planted August 28th, 1926. Harvested December 21st, 1926.

Each plot = ¼ acre.

TABLE No. 11.

Green Manuring Experiment, 1926.

Plot.	Early Crop.	Late Crop.	Yield per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
B3E. 1	Mucuna	Cotton	308	
2	Dolichos ...	„	324	− 6
3	Mucuna	„	352	
4	Canavalia ...	„	380	+ 38
5	Mucuna	„	332	
6	Cowpeas ...	„	400	+ 50
7	Mucuna	„	368	
8	Dolichos ...	„	416	+ 8
9	Mucuna	„	448	
10	Canavalia ...	„	360	− 20
11	Mucuna	„	312	
12	Cowpeas ...	„	404	+ 50
13	Mucuna	„	396	

Each plot $\frac{1}{7}$ acre. Green Manure sown March 5th, dug in June 28th.

Cotton sown July 12th. Harvested December 21st—March 11th.

Average yield of 7 plots cotton following Mucuna 359

Average difference of 2 plots cotton following Dolichos ... + 1 ± 32

Average difference of 2 plots cotton following Canavalia .. + 9 ± 32

Average difference of 2 plots cotton following Cowpeas ... + 50 ± 32

R = 45.

TABLE No. 12.

Cover Crop Experiment—1926.

Plot.	Late season treatment.	Crop.	Yield of dry grain lb. per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
YIS. 1	Dolichos	Maize	890	
2	Canavalia	,,	1,094	− 90
3	Dolichos	,,	1,478	
4	Mucuna	,,	1,084	− 225
5	Dolichos	,,	1,140	
6	Cowpeas	,,	922	− 240
7	Dolichos	,,	1,184	
8	Canavalia	,,	834	− 252
9	Dolichos	,,	989	
10	Mucuna	,,	1,039	+ 3
11	Dolichos	,,	1,084	
12	Cowpeas	,,	1,084	− 50
13	Dolichos	,,	1,184	
14	Dolichos dug in December 1st	,,	1,468	+ 54
15	Dolichos	,,	1,645	
16	Weeds	,,	1,084	− 516
17	Dolichos	,,	1,556	
18	Weeds dug in December 1st and January 1st	,,	1,106	− 311
19	Dolichos	,,	1,278	
20	Dolichos	,,	(1,878)	Non-experimental
	Average		1,243	

Lagos White maize sown 19th April, 1926. Harvested 13th August, 1926.

Each plot = 0·18 acres.

Average increase 2 plots following Canavalia as compared with Dolichos ... ... −171±213

Average increase 2 plots following Mucuna as compared with Dolichos ... ... −111±213

Average increase 2 plots following Cowpeas as compared with Dolichos ... ... −145±213

Increase 1 plot following Dolichos dug in December 1st, 1926 ... + 54±301

Increase 1 plot following Weeds ... ... −516±301

Increase 1 plot following Weeds cultivated December 1st and January 1st, 1927 ... ... −311±301

R = 301.

TABLE No. 13.

Manurial Experiment, A3N. 1926.

Early Cropping—Maize.

Plot.		Treatment.	Yield in dry grain, lb. per acre.		Increase (+) or decrease (−) compared with mean of adjacent controls.
A3N	1	Control plot, no manure... ...	364		
	2	10 cwt. cotton seed		560	+ 76
	3	Control plot, no manure ...	604		
	4	13 cwt. rock phosphate		336	− 164
	5	Control plot, no manure... ...	396		
	6	13 cwt. cotton seed and 13 cwt. rock phosphate		612	+ 56
	7	Control plot, no manure... ...	716		
	8	13 cwt. cotton seed		584	+ 4
	9	Control plot, no manure... ...	444		
	10	10 cwt. rock phosphate		436	
	11	Control plot, no manure ...	428		
	12	13 cwt. cotton seed and 10 cwt. rock phosphate		344	− 80
	13	Control plot, no manure ...	420		
		Average	482		

R=215

Average yield of 7 control plots, 482 lb. per acre.

,, difference of 2 plots, manured with cotton seed ... ... +40±152

,, ,, ,, 2 ,, ,, ,, phosphate ... ... −82±152

,, ,, ,, 2 ,, ,, ,, phosphate and cotton seed ... −12±152

Note :—The above crop was so complete a failure that no reliability can be placed on the figures.

TABLE No. 14.

MANURIAL EXPERIMENT. (LATE CROP).

No. of plot.		Treatment.	Crop.	Yield.		Increase (+) or decrease (−) compared with mean of adjacent controls.
A3N	1	No Manure	Cotton	164		
	2	13 cwt. cotton seed ...	,,		224	+ 38
	3	No Manure	,,	208		
	4	10 cwt. rock phosphate ...	,,		192	− 6
	5	No Manure	,,	188		
	6	13 cwt. cotton seed and 10 cwt. rock phosphate	,,		216	+ 14
	7	No Manure	,,	216		
	8	13 cwt. cotton seed ...	,,		196	− 6
	9	No Manure	,,	188		
	10	10 cwt. rock phosphate ...	,,		196	− 8
	11	No Manure	,,	220		
	12	13 cwt. cotton seed and 10 cwt. rock phosphate	,,		216	− 16
	13	No Manure	,,	244		

Each plot ¼ acre. Cotton sown July 15th, 1926. Harvested December 22nd to March 7th, 1927.

Average yield of 7 plots, unmanured		204
,, difference of 2 plots, manured with cotton seed ...		+ 16±21
,, ,, of 2 ,, ,, ,, rock phosphate ...		− 7±21
,, ,, of 2 ,, ,, ,, both cotton seed and phosphate		− 1±21

R=30

TABLE No. 14—*continued.*

Manurial Experiment.

No. of plot.		Treatment.	Crop.	Yield.		Increase (+) or decrease (−) compared with mean of adjacent controls.
A38	14	No Manure	Cotton after Green Manure.	356		
	15	13 cwt. cotton seed ...			304	— 34
	16	No Manure		320		
	17	10 cwt. rock phosphate ...			328	+ 26
	18	No Manure		284		
	19	13 cwt. cotton seed and 10 cwt. rock phosphate			316	+ 38
	20	No Manure		272		
	21	13 cwt. cotton seed ...			268	— 106
	22	No Manure		476		
	23	10 cwt. rock phosphate ...			456	— 36
	24	No Manure		508		
	25	13 cwt. cotton seed and 10 cwt. rock phosphate			568	— 4
	26	No Manure		636		

Each plot ¼ acre. Cotton sown July 15th, 1926. Harvested December 22nd to March 7th, 1927. Green Manure dug in June 23rd, 1926.

Average of 7 unmanured plots 407

„ difference of 2 manured with cotton seed ... − 70±72

„ „ „ 2 „ „ phosphate ... − 5±72

„ „ „ 2 „ „ both ... ... +17±72

R=102

TABLE No. 15.

Bush Fallowing Experiment Z2. 9 Acres—Early Cropping.

Plot.	Previous Treatment.	Yields lbs. dry grain maize per cwt.		Increase (+) or decrease (−) compared with mean of adjacent controls.
Z2.				
Plot 2	Cultivated continuously ...	972		
3	Two years' fallow—woody weeds removed yearly ...		1,106	+ 108
4	Cultivated continuously ...	1,024		
5	Three years' fallow—woody weeds removed yearly ...		1,242	+ 248
6	Cultivated continuously ...	964		
7	Three years' fallow—woody weeds left		1,300	+ 283
8	Cultivated continuously ...	1,070		
9	Three years' fallow—bush burnt yearly		1,190	+ 294
10	Cultivated continuously ...	723		
12	Cultivated continuously ...	916		
13	Three years' fallow—bush burnt yearly		1,104	− 34
14	Cultivated continuously ...	1,360		
15	Three years' fallow—woody weeds left		1,426	+ 228
16	Cultivated continuously ...	1,036		
17	Three years' fallow—woody weeds removed yearly ...		1,464	+ 328
18	Cultivated continuously ...	1,236		
19	Two years' fallow—woody weeds removed yearly ...		1,280	+ 36
20	Cultivated continuously ...	1,252		
	Average	1,055		

R = 245.

Average yield 10 plots cultivated continuously 1,055

Average difference 2 plots two years' fallow—woody weeds removed yearly + 72 ± 173

Average difference 2 plots three years' fallow—woody weeds removed yearly + 288 ± 173

Average difference 2 plots three years' fallow—woody weeds left ... ... + 255 ± 173

Average difference 2 plots three years' fallow—bush burnt yearly ... ... + 130 ± 173

Average difference 8 plots two or three years' fallow ... ... + 186 ± 87

TABLE No. 16.

Bush Fallowing Experiment—1926 Late Cropping Z2N—Maize.

Plot.	Previous Treatment.	Yield of maize lb. dry grain per acre.	Increase (+) or decrease (−) compared with mean of adjacent control.
Z2N.			
2	Cultivated continuously 1922–25	634	
3	Two years' bush—woody weeds removed 1922–25	816	+ 143
4	Cultivated continuously 1922–25	712	
5	Three years' bush—woody weeds removed 1922–25	816	+ 132
6	Cultivated continuously 1922–25	656	
7	Three years' bush—woody weeds left 1922–25	896	+ 244
8	Cultivated continuously 1922–25	648	
9	Three years' bush—bush burnt annually 1922–25	844	+ 250
10	Cultivated continuously 1922–25	541	
	Average	638	

R = 72.

Average yield of 5 plots cultivated continuously from 1922–25... ... ... 638 lb. per acre.
Average difference of 1 plot, two years in bush and woody weeds removed annually 1922–25 ... ... + 143 ± 72
Average difference of 1 plot, three years in bush and woody weeds removed annually 1922–25 ... ... + 132 ± 155
Average difference of 1 plot, three years in bush and woody weeds left annually 1922–25 ... ... + 244 ± 72
Average difference of 1 plot, three years in bush and bush burnt annually 1922–25 ... ... + 250 ± 72
Average difference of 4 fallow plots above ... ... + 192 ± 36
Maize planted August 30th, 1926. Harvested December 21st. 1926.
Each plot = ½ acre.

TABLE No. 17.

TREATMENT OF COVER CROPS EXPERIMENT, 1926, 5 ACRES.

Plot.	Treatment.	Crop.	Yield per acre lb. dry grain.		Increase (+) or Decrease (−) compared with mean of adjacent control.
C5N. 1	Cover crop cut in March and dug in at once	Maize.		(2,224)	
2	Cover crop burnt in March and plot dug	,,	2,320		
3	Cover crops burnt in March and plot moulded up	,,		2,064	− 112
4	Cover crop burnt in March and plot dug	,,	2,032		
5	Cover crop burnt in March and plot moulded up	,,		1,968	− 144
6	Cover crop burnt in March and plot dug	,,	2,192		
7	Cover crop burnt in March and plot moulded up	,,		2,088	+ 62
8	Cover crop burnt in March and plot dug	,,	1.860		
9	Cover crop burnt in March and plot moulded up	,,		2,288	+ 314
10	Cover crop burnt in March and plot dug	,,	2.088		
	Average		2,098		+ 30 ± 115
11	Cover crop cut in November and dug in at once	,,	2,452		
12	Cover crop cut in November and dug in in March ...	,,		2,404	+ 10
13	Cover crop cut in November and dug in at once.	,,	2,336		
14	Cover crop cut in November and dug in at once	,,		2,340	46
15	Cover crop cut in November and dug in at once	,,	2,436		
16	Cover crop cut in November and dug in in March ...	,,		2,176	− 38
17	Cover crop cut in November and dug in at once	,,	1,992		
18	Cover crop cut in November and dug in in March ...	,,		2,044	− 16
19	Cover crop cut in November and dug in at once	,,	2,128		
20	Cover crop burnt in and dug in at once	,,		(1920)	...
	Average		2,269		− 22 ± 122

Average yield of 5 plots burnt in March and dug. ... 2,098 lb. per acre.
Average difference of 4 plots burnt in March and moulded up + 30 ± 115
Average yield of 5 plots cut in November and dug in at once 2,269.
Average difference of 4 plots cut in November and dug in March − 22 ± 122.
Yield of one plot burnt in March and dug in at once 1,920.
Yield of one plot cut in March and dug in at one 2,224.
R = 231 (plots 2–10).
R = 244 (plots 11–19).
Maize planted April 17th, 1926. Harvested August 9th, 1926.

TABLE No. 18.

Dry Season Experiment, 1926.

Cover Crop followed by Early Maize.

Plot B7 & 8.	Treatment.	Yield per acre, dry grain lb.		Increase (+) or decrease (−) compared with mean of adjacent controls.
		Controls.	Treatments.	
Plot 1	Dug at beginning of dry season	2,016		
2	Dug at the end of dry season		2,228	+ 12
3	Dug at beginning of dry season	2,416		
4	Dug at the end of dry season		2,388	− 32
5	Dug at beginning of dry season	2,424		
6	Dug at the end of dry season		2,448	− 12
7	Dug at beginning of dry season	2,496		
8	Dug at the end of dry season		2,312	− 30
9	Dug at beginning of dry season	2,188		
10	Dug at the end of dry season		2,280	+ 76
11	Dug at beginning of dry season	2,220		
12	Dug at the end of dry season		1,964	− 270
13	Dug at beginning of dry season	2,248		
14	Dug at the end of dry season		1,924	− 488
15	Dug at beginning af dry season	2,576		
16	Dug at the end of dry season		2,304	− 76
17	Dug at beginning of dry season	2,184		
	Average	2,308		− 102 ± 90

R = 256.

Average yield of 9 plots dug in at beginning of dry season 2,308 lb. per acre.

" difference of 8 plots dug in at the end of dry season − 102 ± 93.

TABLE No. 19.

STUMPING EXPERIMENT.

(Commenced 1926).

Crop—Maize.

Plot. C6S.	Treatment.	Yields lb. dry grain per acre.		Increase (+) or decrease (−) compared with mean of adjacent controls.
Plot 24	Control plot	1,919		
25	Stumped and to be rotated ...		1,924	− 23
26	Control plot	1,975		
27	To be rotated but not to be stumped		1,874	− 52
28	Control plot	1,878		
29	Stumped and to be rotated ...		2,157	+ 111
30	Control plot	2,215		
31	Rotated but not to be stumped		2,174	− 102
32	Control plot	2,338		
33	Stumped and not to be rotated		2,232	− 90
34	Control plot	2,307		
35	Rotated but not to be stumped		2,042	− 270
36	Control plot	2,317		
37	Stumped and not to be rotated		2,292	+ 45
38	Control plot	2,177		
39	Rotated but not to be stumped		2,008	− 72
40	Control plot	1,983		
	Average	2,123		

R = 158 lb. per acre.

Average yield of 9 control plots, unstumped ... ... 2,123 lb. per acre.

„ difference of 4 plots, stumped and to be rotated + 11 ± 79.

„ „ 4 „ not stumped and to be rotated − 124 ± 79.

Maize planted 16th April, 1926. Harvested 9th August, 1926.

Each plot = 0.2365 acre.

TABLE No. 20.

Yield of Yams (Ya) four year Rotation Experiment

(Fourth year).

TABLE (1).

Plot 1	... 3,866 (lb. per acre tubers)		Plot 6	... 8,432 (lb. per acre tubers)	
2	... 5,374	,,	7	... 7,554	,,
3	... 4,078	,,	8	... 5,234	,,
4	... 7,264	,,	9	.. 6,108	,,
5	... 5,940	,,	10	... 4,092	,,

TABLE (2).

Average yield per acre under the various Rotations.

Rotation No.	I.	II.	III.	IV.	V.
	3,866	5,374	4,078	7,264	5,940
	8,482	7,554	5,234	6,108	4,092
Average ...	6,174	6,464	4,656	0,686	5,016

TABLE (3).

Average yield per acre under the various Rotations but calculated on % germination.

Rotation No.	I.	II.	III.	IV.	V.
	7,440	8,640	8,156	11,180	11,200
	12,820	12,410	8,720	10,720	6,180
Average ...	10,130	10,525	8,438	10,950	8,690

TABLE (4).

Rotations.	I.	II.	III.	IV.	V.
1st Year ...	Mucuna and cotton	Mucuna and Cotton	Mucuna and Cotton	Groundnuts and Cotton	Groundnuts and Cotton
2nd ,, ...	Mucuna and Maize	Maize and Cover Crop	Groundnuts and Cover Crop	Maize and Maize	Maize and Cowpeas
3rd ,, ...	Groundnuts and Cover Crop	Groundnuts and Cover Crops	Maize and Maize	Groundnuts and Cover Crops	Maize and Maize
4th ,, ...	Yams and Dolichos	Yams and Dolichos	Yams and Dolichos	Yams and Dolichos	Yams and Dolichos
Green Manure	2	1	1	—	—
Cover Crop...	2	3	2	2	1
Groundnuts...	1	1	1	2	1
Exhaustive Crops	3	2	4	4	5

TABLE (5).

Yield of Cotton (YB).

Plot 1	560 seed cotton lb. acre	6	656 seed cotton lb. acre
2	614	7	658
3	778	8	720
4	378	9	444
5	570	10	506

Average yield seed cotton per acre 588 lb.

TABLE No. 21.

Cotton through Yams—Meko *versus* Ishan.

Plot.	Variety.	Yield per acre.	Increase (+) or decrease (−) compared mean of adjacent controls.
A7N 4	Meko	576	
5	Ishan ...	663	+ 48
6	Meko	664	
7	Ishan ...	544	− 76
8	Meko	576	
9	Ishan ...	596	+ 28
10	Meko	560	
11	Ishan ...	640	+ 70
12	Meko	580	
13	Ishan ...	592	− 34
14	Meko	672	
15	Ishan ...	740	+ 122
16	Meko	564	
17	Ishan ...	720	+ 166
18	Meko	544	
19	Ishan ...	588	+ 102
20	Meko	428	

Average of 9 plots Meko 574.

„ difference of 8 plots Ishan. $+ 53 \pm 28$.

R = 79.

Each plot ¼ acre. Cotton planted July 12th, 1926. Harvested January 17th–March 17th, 1927.

TABLE No. 22.

Cocoa Yields, 1926.

Plot.	Acreage.	Variety.	Planted.	Yield per acre lb.	
				Wet beans.	Dry beans.
A 1	2·5	Yellow Pod ...	1912	1,359	622
Y 1	4·75	Red Pod	1912	230	103

TABLE No. 22A.

COCOA.—FERMENTATION TEST, 1926.

Lot.		Weight of wet beans taken lb.	Weight of dry beans produced lb.		Ratio of dry to wet weights.	
			Unfermented.	Fermented.	Unfermented.	Fermented.
No. 1	A	461	215	—	46·6%	
	B	461	—	201		43·6%
No. 2	A	797	372	—	46·7%	
	B	797	—	361		45·3%
No. 3	A	397	184	—	46·4%	
	B	397	—	181		45·6%
No. 4	A	20	10	—	46·8%	
	B	60	—	27		44·4%
Totals ...		1,675	781	—	46·6%	
		1,722	—	770	—	44·7%

Taking the above figures, 100 tons of dry unfermented cocoa is produced from the same quanity of wet beans as 96 tons of fermented, *i.e.*, Loss through fermenting = 4% on dry weight.

TABLE No. 23.

PALM TAPPING—1926.

No. of tree.	No. of periods.	Total No. of days in the periods.	Yield of wine in galls.	Yield of wine, 1917–1926 in galls.	Remarks.
1	...	...	...	72·94	Felled 1922.
2	9	105	1·04	109·59	
3	...	...	...	28·65	Only yielded for two years.
4	...	...	...	29·60	do.
5	...	...	...	19·52	Yielded once in 1925.
6	...	...	...	27·34	
7	12	122	1·20	108·19	
8	...	...	...	41·09	Only yielded for four years.
9	2	19	·016	28·736	
10	15	135	·98	56·26	

TABLE No. 24.

GBANJA KOLA (JANUARY TO DECEMBER), 1926.

Acreage = 2·5 acres.

2·5 acres. Planted 15′ × 15′ in 1913.

No. of Plot.	No. of collections.	No. of pods.	Weight of pods. in lb.	No. of Nuts.	Total weight of seed or nuts.	Yield of nuts per acre in lb.
Y5	58	7,056	2,692¾	27,203	1,164lb.	466lb.

TABLE No. 25.

Coffee, 1926.

Planted 12′ × 12′ in 1915.

Plot.	Variety.	Area.	Yield of fresh berries per plot in lb.	Yield of parchment coffee per plot in lb.	Yield of parchment coffee lb. per acre.	Remarks.
A. 2 SE.	Abeokuta	1 acre	214	66½	66½	Trees in alternate rows severley pruned in 1925.

TABLE No. 26.

Coconuts, 1926.

No. of Plot.	Area Acre.	Planting Distance.	No. of trees at end of year.			Vacancies.	No. of collection.	Yield.			
			Bearing.	Non-bearing	Young Plants.			Good.	Bad.	Total.	% Bad.
B1	5	30′ × 30′	159	83	7	37	4	5,481	834	6,315	13·2%
C1	5	25′ × 25′	192	146	17	42	4	2,744	888	3,632	24·4%

TABLE No. 27.

Oil Palm, Wild, 1926–27.

Block.	Treatment.	Acreage.	No. of collections.	No. of trees from which collected.	Total No. of bunches.	Total weight of bunches.	Average weight per bunch.	Weight of bunches per bearing palm.	Weight of bunches per acre.
						lb.	lb.		
A6 Y	Cultivated	2½	11	84	158	1,968·2	12·5	23·4	3,936·4
A6 A	Uncultivated	2½	11	212	373	5,242·9	14	24·9	10,485·8
Z6 X	Uncultivated	2	9	27	56	762	13·6	28·2	1,524
Z6 B	Cultivated	3	10	140	238	3,052·7	12·4	21·9	6,105·4

TABLE No. 28.

Cost of Cultivation of main Annual Crops—1926.

Figures in man-days per acre obtained from plots of the Main Rotation.

Crop.	Preparation.	Establishing.	After cultivation.	Harvesting.	Store work.	Total.	
1. Yams and	44	134	39	37	3·5	257·5	
Cover Crop ...	...	3	24	...	..	...	
2. Green Manure and	3	8	15*	...	...	26	142·5
Cotton	46·5	4	33	24	9	116·5	
3. Groundnuts and ...	42	13·5	19·5	61	9	145	
Cover Crop ...	...	3	16·25*	...	...	...	
4. Maize and ...	37	10	9	11	1	68	79
Cover Crop ...	3	4	4	...	...	11	
5. Late Maize ...	30	6	26*	11	1	74	

* Note :- High figures here due to dhub weeding.

TABLE No. 29.

Comparison of Costs of Production and Revenue for Main Rotation Crops, 1926–27 Season, Moor Plantation.

Cost of labour=11d. per man-day.

Crops.	Cost of crop in man-days per acre.	Average yield per acre lb.	Cost of production of crop in man-day per lb.	Market value per lb.	Calculated return per acre.	Gross Monetary return per man-day.	Kind of crop.
					£ s. d.		
Yams and Cover Crop	257·5	7,892	·035	·43d.	14 2 11	13·18d.	Tubers.
Green Manure and cotton ...	142·5	494	0·29	1/1 16d.	2 3 9	*3·7d.	Seed cotton.
Cotton through Yams ...	74	494	0·15	1/1 16d.	2 3 9	7·1d.	Seed cotton.
Groundnuts and Cover Crop ...	145	1,856	0·78	1·00d.	7 14 8	12·8d.	Undecorticated.
Maize and Cover Crop ...	68	3,048	·0223	·321d.	4 1 6	14·38d.	Husked cobs.
Late Maize ...	74	1,564	·043	·536d.	3 9 10	11·3d.	Husked cobs.

Note:—*If the cost of the green manure is not charged to the cotton, the gross monetary return per man-day is approximately 4·5d.

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KOLA (Table No. 1).

In the year 1923 it became obvious that the kola trees which had originally been spaced at fifteen feet square were too close, and thinning out was begun. The surviving trees in all plots are now spaced at an average distance of about twenty-four feet square. The yields for the past few seasons have been as follows:—

7 Acres Kola Trees Planted Out in the Year 1911.

Season.	Yield of good nuts lb. per acre.
1922	716
1923	532
1924	546
1925	838
1926	424

It will be seen that the yield for 1926 was lower than usual, but this may have partly been due to theft.

COCOA (Table No. 2).

The average yield was three hundredweight of dry cocoa per acre, equivalent to three and-a-half pounds per bearing tree. When it is considered that the plots are patchy in places and that the rainfall was only forty-four inches, this yield was very satisfactory. The highest yield obtained in a non-experimental plot was six hundredweight of dry beans per acre or slightly more than four pounds per bearing tree. The table below shows the yeilds for the past few years.

16 Acres Cocoa Trees Planted Out in the Year 1910.

Season.	Yield of dry cocoa lb. per acre.
1922	314
1923	490
1924	362
1925	306
1926	339

The plots were originally planted out with the object of deciding whether twelve feet spacing or fifteen feet spacing was the better; the results obtained are neither consistent nor reliable, owing to the death of so many trees in recent years.

Three small experiments have been carried out recently in the Agege cocoa plots. These tests were laid down in the year 1923, when small adjacent plots were marked out in the established cocoa then thirteen years of age; they will now be discontinued as they have not given reliable results, mainly on account of the death of so many trees, and partly due to the number of plots being insufficient. An examination of Tables 3, 4 and 5, shows that in the cultivation and pruning experiments less than half, and in the mulching test barely half, of the trees are now of bearing age. The plots are now very patchy and show no observable difference on account of the treatments to which they have been subjected. The yields per bearing tree do not give results which differ appreciably from the yields per acre. The results for the past season and other points of interest are detailed below.

	Yield of Cocoa in lb. per acre	per bearing tree.
CULTIVATION TEST. (Table No. 3).		
Average yield 2 plots uncultivated	554	3·6
„ „ „ „ cultivated	556	3·8
MULCHING TEST. (Table No. 4).		
Average yield 2 plots mulched...	625	5·6
„ „ „ „ unmulched	655	6·5
PRUNING TEST. (Table No. 5).		
Average yield 2 plots pruned	496	4·7
„ „ „ „ unpruned	240	3·7

In the cultivation test the cultivated plots were thoroughly forked at the end of the rainy season each year. The yields in the season 1926 were practically identical for the cultivated and uncultivated plots. Since 1923, fifty-four trees of bearing age have died in the cultivated plots, and twenty-nine trees in the uncultivated; but it is not known if the cultivation assisted in killing the trees, for the cause of death has not always been recorded. Attention is drawn to the high yield of 796 lb. per acre for plot 4 in A1.

In the mulching test, the trees in the mulched plots were supplied with a covering of green stuff, usually banana leaves, at the beginning of each dry season. Since 1923, sixteen trees of bearing age have died in the mulched plot, and twenty in the unmulched. The mulched trees have given a slightly lower yield per acre and per bearing tree, but no reliance can be placed on these results.

In the pruning test, the apparent increased yield due to pruning was entirely due to plot 1, which has turned out to be an especially good plot and gave a yield of 6.3 lb. per bearing tree. An

examination of the plots does not show any striking difference between the pruned and the unpruned cacao trees, for the latter have not developed into the rambling trees that one would have expected. As with the other tests, this experiment is not likely to give any useful result and will be discontinued.

COSTS.

A comparison of the costs of the kola and cocoa crops is interesting. The figures refer to the season 1926, *i.e.*, from April 1st 1926, to March 31st, 1927.

	Cocoa 16 acres.	Kola 7 acres.
Average yield per acre	339 lb. dry cocoa.	424 lb. good nuts.
	£ s. d.	£ s. d.
Average price per ton realised	48 12 0	37 0 0 (approx.)
„ gross revenue per acre ...	7 5 9	7 16 6
„ cost of labour per acre ...	2 14 9	1 1 3
„ gross profit per acre	4 11 0	6 15 3
Labour in man days per acre	60	23
Cost per man day	11d.	11d.
Return per man day	30d.	82d.

Note.—The average yield per acre of good kola nuts was 9,314, and the average number of nuts in one pound was twenty-two; hence the price per 100 good nuts was 1s. 6d., and the price per pound, 4d. The average yield per acre of very inferior nuts was 1,586 nuts or 54 lb. per acre; this was additional to the yield of good nuts recorded above.

Gross profit in the table above represents the revenue obtained from the crop less the cost of labour. No allowance has been made for such items as rent of land, cost of clearing and establishing the crop, or supervision; but this does not make the figures any the less valuable for comparative purposes.

These figures show that kola has again paid better than cacao at Agege in the past season, despite the high price ruling for cacao and the comparatively low yield of kolas obtained. The kola plots show a gross profit £2 4s. 3d. greater than that obtained for the cacao plots, and the return per man day was 6s. 10d. as compared with 2s. 6d. for cacao.

Revenue exceeded expenditure on labour for the whole of Agege Farm by about £30. The revenue is derived almost entirely from the kola and cacao plots, and the expenditure includes the upkeep of twenty-four acres of hevea rubber, the repair of a rest house and the pay of messenger and office watchman. Figures for the season 1926 were:—

	£	s.	d.
Sales of produce	174	16	8
Cost of labour	145	0	6

I am indebted to J. A. Aladegbaiye, Overseer, Agege Farm, for recording the yields and sales, and to H. G. Poynter, Superintendent of Agriculture, and J. A. Obaseki, Agricultural Assistant, for working out and checking the figures given in this report.

H. B. WATERS.

TABLE No. 1.

KOLA (VARIETY—GBANJA). YIELDS FOR SEASON, 1926.

All plots were originally planted out in 1911.

Plot No.	Acreage.	Orginal spacing.	No. of trees per plot.		Yield of good nuts.	
			Bearing.	Not bearing.	lb. per acre.	lb. per bearing tree.
B1	2	15′ × 15′	152	6	678	8·9
B2	2	20′ × 20′	168	5	449	5·4
D1	2	15′ × 15′	101	51	259	5·1
D2	1	20′ × 20′	63	4	197	3·1
		Averages	484	66 trees	424 lb.	6·1 lb.

TABLE No. 2.

Cocoa Yields for season 1926.

All plots were originally planted out in 1910.

Variety.	Plot No.		Acreage.	Original spacing square.	No. of bearing trees per plot.	Yield of dry beans.	
						lb. per acre.	lb. bearing tree.
Yellow Pod	A1	Experimental	1·0	12′	145	555	3·7
		Non-experimental	1·0	12′	112	384	3·4
			2·0		257	470	3·6
	A2	Experimental	0·8	15′	85	641	6·0
		Non-experimental	1·2	15′	110	421	4·6
			2·0		195	509	5·2
	A3		2·0	12′	329	676	4·1
	A4		2·0	15′	108	176	3·2
Red Pod	C1		2·0	12′	232	255	2·2
	C2		2·0	15′	88	98	2·2
	C3		2·0	12′	265	360	2·7
	C4	Experimental	0·62	15′	53	368	4·2
		Non-experimental	1·38	15′	38	72	2·6
			2·00		91	164	3·1
		Totals ...	16 ac.		1,565 trees	339 lb.	3·5 lb.

Percentage weight of pods to wet beans = 383%

Percentage weight of dry beans to wet beans = 42·3%

TABLE No. 3.

Cocoa Cultivation Test. Yields in 1926.

Started in 1923 on Yellow pod cocoa planted out 12′ × 12′ in 1910 with Hevea rubber as shade spaced 48′ × 48′.

Block.	Plot No.	Acreage.	Treatment.	Yield of dry beans lb. per acre.	Trees of bearing Age.		Total No. of trees per plot.	Yield of dry beans lb. per tree of bearing age.
					1923.	1927.		
A1	1	0·2	Cultivated...	312	59	26	75	3·0
	2	„	Uncultivated	336	51	28	„	3·0
	3	„	Cultivated...	776	63	42	„	4·6
	4	„	Uncultivated	796	55	49	„	4·1
			Totals ...	555 lb.	228	145	300	3·71 lb.

TABLE No. 4.

Cocoa Mulching Test.—Yields in 1926.

Started in 1923 on Yellow pod cocoa planted out 15′ × 15′ in 1910 with hevea rubber as shade, spaced 45′ × 45′.

Block.	Plot No.	Acreage.	Treatment.	Yield of dry beans lb. per acre.	Trees of bearing Age.		Total No. of trees per plot.	Yield of dry beans lb. per tree of bearing age.
					1923.	1927.		
A2	1	0·2	Mulched ...	530	31	20	40	5·3
	2	0·2	Unmulched	550	30	18	40	6·1
	3	0·2	Mulched ...	720	30	25	40	5·8
	4	0·2	Unmulched	760	30	22	40	6·9
			Totals ...	640 lb.	121	85	160 trees	6·01 lb.

TABLE No. 5.

Cocoa Pruning Test—Yields in 1926.

Started in 1923 on Red pod cocoa planted out 15′ × 15′ in 1910 with rain trees as shade, spaced 45′ × 45′.

Block.	Plot No.	Acreage.	Treatment.	Yield of dry beans lb. per acre.	Trees of bearing age, 1927.	Total No. of trees per plot.	Yield of dry beans lb. per tree of bearing age.
C4	1	0·155	Pruned ...	705	18	30	6·3
	2	„	Unpruned ...	175	7	30	3·9
	3	„	Pruned ...	286	14	30	3·1
	4	„	Unpruned ...	305	14	30	3·4
			Totals ...	388 lb.	53	120 trees	4·21b.

ANNUAL REPORT—AGRICULTURAL STATION, OGBA, BENIN, 1926.

Progress in both experimental and district work has been made during the past year.

Permanent Crops.

Planted in 1923 onwards, oil palms, cocoa and coffee have commenced to bear. The key note of our present policy is to get all inter-rides not cropped with annual crops for experimental purposes, under cover crops.

I.—Cocoa—Planted 1924-25.

The experiment testing the suitability of various crops at temporary live shade for cocoa has been discontinued. Cassava seemed definitely injurious both from its overshading effect and from its exhaustive effect on the soil. Pigeon peas appeared worthy of further trial. Plantains placed midway between the cocoa gave most promise and their use is being extended to other areas of cocoa.

In the comparison between (1) plots forked all over and kept clean weeded and (2) vegetable mulched plots, as against standard plots on which the bush was merely kept cut back, vegetable mulched plots showed signs of superiority both from the point of view of vegetable growth and from that of early flowering.

II.—Oil Palms.

For the second time the yield of yams per acre does not appear to have been affected by the presence of a number of palms growing in the plots. The palms are now three years old. *See* Table No. 1.

	Lb. per acre.	Odds.
Average yield in lb. per acre of three control plots with no palms	4 151	—
Difference of one plot containing 21 palms	+470 ± 122	7 : 1
Difference of one plot containing 33 palms	−326 ± 422	3 : 1

ANNUAL CROPS.

I.—Cover Crop Experiments.

Experiments were designed and commenced during the year:—

(*a*) To test the merits of dolichos *versus* mucuna as a late (dry season) cover crop.

(*b*) To test the value of dolichos as compared with mucuna, centrosema and crotolaria as green manures. (There is some doubt as to the specific name of the latter; recent correspondence indicates that it is probably not crotolaria.) To the eye centrosema and crotolaria are much superior as weed excluders.

In 1925 crotolaria (?) proved best. *See* Table No. 2.

	Lb. per acre	Odds.
Average yield of 10 plots of yams following Dolichos	8,731	—
Average difference of 3 plots following Crotolaria (?)	+319±483	2 : 1
Average difference of 3 plots following Centrosema	−277±483	2 : 1
Average difference of 3 plots following Mucuna	−437±483	3 : 1

(*c*) To investigate the desirability of twice planting mucuna (once at the beginning of the rains and again about July) when required as a long period cover crop as opposed to allowing it to struggle on for a whole year.

(*d*) To find the effect of burning a cover crop (in this case crotolaria—a woody shrub) as against cutting and leaving the green manure to rot, on a subsequent crop of maize. In both above cases a test crop will be planted in 1927 as a measure of the effects obtained.

II.—Yams.

A spacing test was carried out for this crop, as the native method of planting six feet by four feet seemed uneconomical. The spacings used on six feet ridges in all cases were four feet, three feet, and two feet respectively. The last named gave a superior yield not only in actual weight per acre but also in the amount of large saleable tubers, *i.e.*, the increase in weight was not merely due to an increased number of very small tubers. *See* Table No. 3.

	lb. per acre.	Odds.
Average yield per acre of 9 plots of yams planted 4′ apart	8,067	
Average difference per acre of 4 plots yams planted 2′ apart	+3,536 ± 380	over 100,000 : 1
Average difference per acre of 4 plots of yams planted 3′ apart	+ 882 ± 380	100 : 1

In this neighbourhood the edible portion of the yam is cut off near the crown, at the appropriate time, and the latter allowed to develop as " seed " yam; such seed was compared with small edible tubers of similar weight. The " seed " shows a superiority in yield over that of small whole edible tubers. *See* Table No. 4.

	Lb. per acre.	Odds.
Average yield per acre of 5 plots with Seed Yams	7,851	—
Average difference per acre of 4 plots planted with small tubers	−1,174±560	55 : 1

III.—Maize.

In 1925 an experiment was laid down to find the effect on a subsequent maize main crop of (I), mucuna; (II), a local edible bean called " Iheme " (Bini) (*phaseolus lunatus* variety) and (III), maize planted the preceding year. The mucuna proved definitely beneficial. " Iheme " had little effect. *See* Table No. 5.

	Maize Cobs lb. per acre	Odds.
Average yield of 9 plots following Mucuna	1,567	—
Average difference of 4 plots after Maize	−474±145	1,448 : 1
Average difference of 4 plots after "Iheme"	−250±145	6 : 1

Native Practice *versus* Continuous Farming.

The experiment carried out in 1925, *viz.*, to compare over a period of years plots farmed by local men on their own lines exactly, as against two sets of ridged (six feet) plots, four stumped, four unstumped, which are farmed on a rotation, but in all of which the number of plants per acre are the same, was repeated. The plots to which Table VI refers are duplicates on different land to that mentioned in last year's report (Fifth Bulletin pp. 178 and 180). Again yams only are grown in all plots. The seed used throughout was remarkably uniform and the quantities planted exactly the same in each plot. The ridged (continuously) cropped plots have given a definite superior yield this year. In 1925 the results were inclusive. *See* Table No. 6.

	Lb. per acre.	Odds.
Average yield of yams in lb. per acre of 9 standard Native Practice Plots ...	8,106	—
Average difference of 4 plots stumped and ridged	+1,504± 757	43 : 1
Average difference of 4 plots unstumped and ridged	+1,566± 757	43 : 1

S. M. GILBERT,

May, 1927.

Rainfall 1926.

Experimental Farm, Ogba, near Benin City.

Months.	Rainfall in inches.	Months.	Rainfall in inches.
January	0·15	July	8·20
February	1·93	August	4·77
March	3·68	September ...	9·91
April	5·79	October ...	8·42
May	10·96	November ...	2·39
June	16·65	December ...	0·00
		Total ...	72·85

Average rainfall for four years from 1923–26 inclusive = 70·14 inches.

TABLE No. 1.

To find the effect of various densities of Palms per acre on the yield of inter-crop.

Plot No.	Treatment	Total weight lb. per acre yams.	Increase (+) or decrease (−) compared with mean of adjacent control.
P 1	No Palms ...	3,860	--
2	33 Palms ...	3,809	− 326
3	No Palms ...	4,410	—
4	21 Palms ...	4,766	+ 470
5	No Palms ...	4,182	--

Increase (+) or decrease (-) due to presence of 33 palms is	Increase (+) or decrease (−) due to presence of 21 palms
− 326 ± 422 lb. per acre.	+ 470 ± 422 lb. per acre.

Root—mean—square—difference between pairs of neighbouring controls:— 422 lb. per acre.

Size of Plot—1 acre.

Variety of Yam — "Ikpe," a yellow yam.

TABLE No. 2.

To study the effect upon the fertility of the Soil of various Cover Crops.

Plot No.	Treatment.	Weight of yams in lb. per acre.		Increase (+) or decrease (−) compared with mean of adjacent controls in lb.
Y. 3	Dolichos	7,976		
4	Crotolaria		8,254	− 686
5	Dolichos	9,904		
6	Centrosema		9,266	− 420
7	Dolichos	9,468		
8	Mucuna		8,482	− 480
9	Dolichos	8,456		
10	Crotolaria		9,536	+ 988
11	Dolichos	8,640		
12	Centrosema		8,386	− 144
13	Dolichos	8,420		
14	Mucuna		8,126	− 430
15	Dolichos	8,692		
16	Crotolaria		9,638	+ 655
17	Dolichos	9,274		
18	Centrosema		8,628	− 269
19	Dolichos	8,520		
20	Mucuna		7,850	− 391
21	Dolichos	7,962		

Increase (+) or decrease (−) of plots following Crotolaria (?) as compared with Dolichos.	Increase (+) or decrease (−) of plots following Centrosema as compared with Dolichos.	Increase (+) or decrease (−) of plots following Mucuna as compared with Dolichos.
− 686 lb. per acre.	− 420 lb. per acre.	− 480 lb. per acre
+ 988 „ „ „	− 144 „ „ „	− 430 „ „ „
+ 655 „ „ „	− 269 „ „ „	− 391 „ „ „
Average + 319 ± 483 lb. per acre.	− 277 ± 483 lb. per acre.	− 434 + 483 lb. per acre.

Root—mean—square—difference between neighbouring control plots—837 lb. per acre

Each plot ¼ acre.

TABLE No. 3.

To learn the most economic Spacing for Yams.

Plot No.	Treatment Spacing.	Total yield lb. per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
W. 30	4 feet by 6 feet	8,604	
31	2 „ „ 6 „	12,112	+ 3,760
32	4 „ „ 6 „	8,040	
33	3 „ „ 6 „	8,978	+ 1,120
34	4 „ „ 6 „	7,676	
35	2 „ „ 6 „	10,912	+ 2,816
36	4 „ „ 6 „	8,516	
37	3 „ „ 6 „	10,200	+ 1,686
38	4 „ „ 6 „	8,512	
39	2 „ „ 6 „	11,676	+ 3,752
40	4 „ „ 6 „	7,336	
41	3 „ „ 6 „	8,194	+ 428
42	4 „ „ 6 „	8,196	
43	2 „ „ 6 „	12,112	+ 3,819
44	4 „ „ 6 „	8,390	
45	3 „ „ 6 „	8,126	+ 294
46	4 „ „ 6 „	7,274	

Increase (+) or decrease (−) of 4 plots planted at 2′ interval in row as compared with those planted 4′ apart.	Increase (+) or decrease (−) of 4 plots planted 3′ apart as compared with those planted 4′ apart.
+ 3,760 lb. per acre.	+ 1,120 lb. per acre.
+ 2,816 „ „ „	+ 1,686 „ „ „
+ 3,752 „ „ „	+ 428 „ „ „
+ 3,819 „ „ „	+ 294 „ „ „
Average + 3,536 ± 380 lb. per acre.	Average + 882 ± 380 lb. per acre.

Root—mean—square—difference between parts of neighbouring controls—760 lb. per acre.

Each plot ¼ acre.

Variety :—Yellow yam called "Ikepe" in Bini.

TABLE No. 4.

To compare the Returns obtained from growing "Seed" Yams with that from small Edible Yams.

Plot No.	Treatment.	Total yield lb. per acre.		Increase (+) or decrease (−) compared with mean of adjacent controls.
Z. 71	Seed Yams	6,952		
72	Small Tuber ...		5,652	− 2,209
73	Seed Yam	8,770		
74	Small Tuber ...		6,270	− 1,956
75	Seed Yam	7,682		
76	Small Tuber ...		8,730	+ 795
77	Seed Yam	8,188		
78	Small Tuber ...		6,602	— 1,325
79	Seed Yam	7,666		
	Average ...	7,851		— 1,174 ± 560

$\frac{1}{4}$ acre plots—Ridges 6′ apart—plants 2′ apart on ridge.

Root—mean—square—difference between pairs of neighbouring controls—1,120 lb. per acre.

Variety used "Ikpe" (Bini)—a yellow yam.

TABLE No. 5.

To study the effect upon the fertility or the soil :—

(*a*) a maize crop

(*b*) a bean crop—"Iheme"

Plot. No.	Treatment.	Weight of Cobs as harvested lb. per acre.	Increase (+) or decrease (−) compared mean of adjacent controls.
Z 29	Mucuna	1,070	
30	Maize	738	− 552
31	Mucuna	1,510	
32	Iheme	1,636	+ 98
33	Mucuna	1,566	
34	Maize	1,160	− 464
35	Mucuna	1,682	
36	Iheme	1,234	− 516
37	Mucuna	1,818	
38	Maize	1,184	− 454
39	Mucuna	1,458	
40	Iheme	1,126	− 252
41	Mucuna	1,298	
42	Maize	1,146	− 425
43	Mucuna	1,844	
44	Iheme	1,520	− 330
45	Mucuna	1,856	

Increase (+) or decrease (−) of plots following Maize.	Increase (+) or decrease (−) of plots following Iheme.
− 552 lb. per acre	+ 98 lb. per acre
− 464 „ „ „	− 516 „ „ „
− 454 „ „ „	− 252 „ „ „
− 425 „ „ „	− 330 „ „ „
− 474 ± 145 lb. per acre	− 250 ± 145 lb. per acre

Root—mean—square—difference between pairs of neighbouring controls—121 lb. per acre.

Each plot ¼ acre. Variety used, local white maize.

TABLE No. 6.

Continuous Cropping Experiment.

Plot No.	Treatment.	Weight of Yams per acre as harvested	Increase (+) or decrease (−) compared with mean of adjacent controls.
W 80	Native Practice ...	7,340	
81	Stumped and Ridged ...	9,510	+ 1,621
82	Native Practice ...	8,438	
83	Unstumped and Ridged	10,610	+ 3,065
84	Native Practice ...	6,652	
85	Stumped and Ridged ...	10,376	+ 2,438
86	Native Practice ...	9,224	
87	Unstumped and Ridged	8.804	+ 479
88	Native Practice ...	7,426	
89	Stumped and Ridged ...	9,600	+ 2,088
90	Native Practice ...	7,598	
91	Unstumped and Ridged	10,280	+ 2,284
92	Native Practice ...	8,394	
93	Stumped and Ridged ...	8,886	− 130
94	Native Practice ...	9,638	
95	Unstumped and Ridged	9,380	+ 438
96	Native Practice ...	8,246	

Average for standard Native Practice plots − 8,106 lb. per acre.

Increase (+) or decrease (−) of plots Stumped and Ridged as compared with Native Practice
+ 1,621 lb. per acre
+ 2,438 „ „ „
+ 2,088 „ „ „
− 130 „ „ „
+ 1,504 ± 757 lb. per acre

Increase (+) or decrease (−) of plots Unstumped and Ridged compared with Native practice
+ 3,065 lb. per acre
+ 479 „ „ „
+ 2,284 „ „ „
+ 438 „ „ „
+ 1,566 ± 757 lb. per acre

Root—mean—square—difference between neighbouring control plots—1,515 lb. per acre.

Each plot $\frac{1}{4}$ acre

Variety—"Ikpe," a yellow yam.

ANNUAL REPORT—ILORIN, 1926.

During the year, experiments have been worked much on the same lines as in previous years. As usual, cotton experiments have taken a very prominent part and owing to the reduced number of cotton stainers the yields are above what is usually obtained.

The following cotton experiments have been carried out:—

(1) Variety test, with cotton as a sole crop.
(2) Variety test through yams, two series.
(3) Time of sowing test with Ishan.
(4) Time of sowing test with Kabba.
(5) Ishan cotton with groundnuts.
(6) Kabba cotton with groundnuts.
(7) Ishan preceded by mucuna *v.* cotton without mucuna.
(8) Half acre of isolated Allen cotton.

The yields were satisfactory on the whole and in one experiment reached 432 lb. of seed cotton per acre. On the other hand the yields of the various cotton experiments in the very poor gravel soil of Block G were so poor that the results are valueless and are not printed. Particulars of the remaining experiments follow.

COTTON VARIETY TEST. COTTON SOLE CROP.

For Details *see* Table I.

	"Seed" cotton lb. per acre.	Odds that difference is significant.
Average yield of 10 plots Ilorin	... 432	
,, difference 4 plots Kabba	... — 168 ± 47	4,350 : 1
,, ,, 4 ,, Ishan	... — 42 ± 47	4 : 1

Under the conditions of the experiment, the indications are that Ilorin is slightly better than Ishan and significantly better than Kabba.

In a time of sowing test this season, it appears that the best sowing date for Kabba is 1st June. The seed in this experiment was sown on July 1st, so that Kabba has not had its best chance of competing with the other two varieties.

As cotton stainers have not been numerous this season, it has been a particularly good year for the earlier maturing varieties, Ilorin and Ishan.

As regards the growth of Ilorin and Ishan, they appear to be very much alike, Kabba differs in being much later in maturing.

COTTON VARIETY TEST THROUGH YAMS (BOKI).

For Details *see* Table II.

	Seed cotton, lb. per acre.	"Odds" that difference is significant.
Average yield of 11 plots Ilorin ...	166	
,, difference of 4 plots Kabba ...	− 10 ± 29	2 : 1
,, ,, ,, 4 ,, Ishan ...	− 27 ± 29	5 : 1

The results indicate that Ilorin is slightly better than Ishan under the conditions of the exeperiment.

There is practically no difference between Ilorin and Kabba. The Kabba variety is a more robust type of plant and is not retarded in its growth when growing through yams to the same degree as are either the Ilorin or Ishan varieties.

As June 1st appears to be the best sowing date for Kabba, shown by another experiment this season, this variety has probably not had as good a chance as the others in this experiment, the seed having been sown on 1st July.

COTTON VARIETY TEST THROUGH YAMS.

For Details *see* Table III.

	Seed cotton lb. per acre.	"Odds" that difference is significant.
Average yield of 11 plots Ilorin ...	152	
,, difference of 5 plots Kabba	− 38 ± 30	9 : 1
,, ,, ,, 4 ,, Isban	+ 2 ± 34	1 : 1

Owing to the fact that in the same plots a variety test of yams was being worked, no conclusions whatever can be drawn from the results.

Both Ilorin and Ishan when grown with the Pansaga variety of yams gave a very much increased yield over what was produced when grown with the Boki variety. In no plot was Kabba grown with Pansaga yams.

Pansaga is an early maturing variety and does not yield a high return, for these reasons it appears that cotton has a much better chance when grown with this variety than with Boki, which is a late maturing variety and a heavy yielder.

White Lisbon yam is between Boki and Pansaga both as regards maturing and weight of crop produced.

The cotton was all sown on July 1st, but it has been determined in another experiment this season that June 1st is very probably the best time to sow the Kabba variety, thus even had other things been equal, the Kabba variety has not had an equal chance with the others.

COTTON VARIETY, KABBA.

Time of Sowing Test.

For Details *see* Table IV.

	Seed cotton lb. per acre.	"Odds" that difference is significant.
Average yield 14 plots July 1st. Sown	185	
„ difference 4 plots June 1st. Sown	+ 26 ± 16	17 : 1
„ „ 4 „ „ 15th. „	+ 13 ± 16	4 : 1
„ „ 4 „ July 15th. „	− 60 ± 16	11,110 : 1

There is a strong indication that June 1st sowing is the best, that June 15th is slightly better than July 1st and that July 15th is significantly worse than July 1st.

This variety of cotton is very late in maturing, and something after the nature of the results obtained was to be expected.

KABBA COTTON WITH GROUNDNUTS

v.

KABBA COTTON ALONE.

For Details *see* Table V.

	Seed Cotton lb. per acre.	"Odds" that difference is significant.
Average yield of 4 plots of cotton with ground-nuts	168	—
Average difference of 3 plots of Cotton alone	+ 104	± 14·4

The results are very definite. Kabba cotton grown with groundnuts has produced only thirty-eight *per cent.* of the quantity produced when grown alone.

Together with groundnuts the results are :—

168 lb. seed cotton plus 1,705 lb. ground-nuts (unhusked) per acre.

Cotton alone gives 271 lb. seed cotton per acre.

The crop values are :—

	Per acre.
(1) With ground-nuts, 168 lb. seed cotton at 1d. per lb.	£0 14 0
1,705 lb. ground-nuts at £11 per ton husked	5 8 9
	£6 2 9
(2) Cotton alone, 271 lb. seed cotton at 1d. per lb.	£1 2 7

Labour expended.

(1) Cotton with ground-nuts 166 man-days per acre.

(2) Cotton alone 62 man-days per acre.

Value of man-days.

(1) Cotton with ground-nuts	£0	0	8·9
(2) Cotton alone	£0	0	4·3

When values are taken into consideration, it is seen that groundnuts with cotton is a better paying proposition to the farmer than cotton grown alone.

Allen Cotton.

A half acre of Allen cotton was grown in an isolated plot and yielded at the rate of 238 lb. seed cotton per acre.

GROUNDNUTS—VARIETY TEST.

For Details *see* Table VI.

Ilorin no. 2 *versus* Zaria, Gambia, Chinese.

	Dry unshelled nuts per acre in lb.	"Odds" that difference is significant.
Average yield 13 plots Ilorin No. 2	1,052	
„ difference 4 plots Zaria	— 96 ± 54·5	24 : 1
„ „ 4 „ Gambia	— 27 ± 54·5	2 : 1
„ „ 4 „ Chinese	— 15·5 ± 54·5	—

Last season the results were :

	Dry unshelled nuts per acre in lb.	"Odds" that difference is significant.
Average yield 13 plots Ilorin No. 2	1,301	
„ difference 4 plots Zaria	+ 89·5 ± 116	4 : 1
„ „ 4 „ Gambia	— 129 ± 116	7 : 1
„ „ 4 „ Chinese	— 9·5 ± 116	1 : 1

Judging from the results of the two years, there does not appear to be any very significiant difference between any of the varieties.

The Ilorin nut is a very small one, Zaria is slightly larger, Gambia and Chinese are larger than either of the Nigerian varieties.

It is proposed during the coming season to commence individual plant selections and to make a further comparative test when the selections have been multiplied sufficiently to enable this to be done.

GROUNDNUTS—SPACING TEST.

FOR DETAILS *see* TABLE VII.

VARIETY ILORIN NO. 2.

STANDS 6″ APART *versus* STANDS 12″ APART AND 18″ APART.

	Dry unshelled nuts per acre in lb.	"Odds" that difference is significant.
Average yield 7 plots stands 6″ apart	990	
„ difference 3 plots stands 12″ apart	+ 123 ± 49·1	160 : 1
„ „ 3 „ „ 18″ „	+ 44 ± 49·1	4 : 1

The experiment was carried out on quarter acre plots with ridges six feet apart and two rows of plants per ridge. The land was in groundnuts followed by cotton last year. Seed was sown April 19th and 20th, and the crop harvested September 20th and 21st.

The results indicate that six inches spacing in double rows is too close, and that eighteen inches spacing in double rows is too far apart. There is a strong indication that twelve inches spacing gives the best results.

YAM VARIETY TEST.

FOR DETAILS *see* TABLE VIII.

	Lb. per acre.	"Odds" that difference is significant.
Average yield of 10 control plots (Boki)	15,321	
„ difference of 4 plots White Lisbon	— 3,194 ± 433	∞ : 1
„ „ 4 „ Pansaga	— 6,972 ± 433	∞ : 1

The results show that both Pansaga and White Lisbon are very poor yielders in comparison with Boki, and that Pansaga does not yield nearly so well as White Lisbon.

Pansaga is an early maturing variety. White Lisbon was imported some years ago from Trinidad, where it is considered a water yam suitable for damp situations. It keeps well during the dry season and always germinates well. It is not much appreciated by the natives and only sells when other varieties have become very scarce.

Boki being a late maturing variety is only appreciated about the middle of the dry season. Earlier than this it contains too much moisture to pound up well in a mortar. It is, however, one of the best varieties to eat roasted.

YAM CAPPING TEST.

A test was made to see in what way capping of yam sets affects the crop. In this Province all farmers cover the earth above each yam set planted with a thick layer of grass or guinea corn leaves, and this is held in place by earth piled up on the top.

The capping is usually done in January and February. The native says he does it because of the sun.

The test was made in a half acre plot of fele yams. Capping was done on three different dates and one set was left uncapped. The results are given below :—

Date of Capping.	No. of sets.	Percentage germination Counted on 29.5.26.	Pounds harvested.
January 7th	428	51%	766
February 1st	414	54%	921
March 1st	422	42%	664
Uncapped	576	2%	84

The results show most decidedly that for the season failure to cap the yams resulted in loss of germination, and that the critical period when caps are required is when germination is taking place.

There are a number of explanations which suggest themselves, but I would not like to say anything till the matter has been further investigated.

From January 1st the rain fell as follows :—

First shower, February 15th, 1.03 inches.
Second shower, March 4th, 0.82 inches.
Third shower, April 4th, 1.21 inches.
Regular rains fell from April 17th.

Further tests are being made this season.

MAIZE SPACING TEST WITH GUINEA CORN.

For Details *see* Table IX.

	Dry grain lb. per acre.	"Odds" that difference is significant.
Average yield of 10 control plots 2 ft. apart in single rows	386	—
Average differece of 3 plots 1½ ft. apart in single rows	+ 99±·3	8 : 1
Average difference of 3 plots 1 ft. apart in single rows	− 79±80·3	5 : 1
Average difference of 3 plots 1 ft. apart in single rows	+309±80·3	1,030 : 1

This experiment was carried out on land with ridges five feet apart, and the results show a decided advantage as regards the weight of maize obtained from planting one foot apart in double rows on the ridges, and the indications are that one and-a-half feet apart is slightly better and one foot apart slightly worse than two feet apart when planted in single rows.

As the native farmer in the Ilorin Province almost always grows maize as a mixed crop with Guinea corn, Guinea corn was sown on the side of each ridge in all the plots, stands being two feet apart.

The combined crops of maize and Guinea corn give the following results. (For further details *see* Table IX.) :—

	Dry grain lb. per acre.	"Odds" that difference is significant.
Average yield of 10 control plots with Maize stands 2 ft. apart in single rows	2,093	—
Average difference of 3 plots with Maize stands $1\frac{1}{2}$ ft. apart in single rows ...	+ 81±137	2 : 1
Average difference of 3 plots with Maize stands 1 ft. apart in single rows	− 330±137	121 : 1
Average difference of 3 plots with maize stands 1 ft. apart in double rows ...	− 214±137	16 : 1

Here there is no practical difference between the combined crops when maize stands are two feet and one and-a-half feet apart. When one feet apart in single rows there is a strong indication that it is not so good as when the stands of maize are two feet apart.

The whole question appears to rest on whether a farmer desires a big maize crop with a little Guinea corn, or a fair crop of both. As a matter of fact, the latter appears to be what he aims at in this Province, and as he sows his maize in stands about two feet apart, the indications are that he is doing the right thing.

MANURIAL VALUE OF MUCUNA *versus* GROUNDNUTS.

In 1925 an experiment was commenced to test the relative values of early mucuna and groundnuts as a preparatory crop for cotton.

The seed of both was sown on April 29th. Mucuna was cut down on July 6th and groundnuts harvested from September 7th to 14th.

The mucuna was buried under ridges made for the cotton and the groundnut tops were covered up as the cotton was moulded up.

Following mucuna, the cotton was sown on the top of the ridges, but with groundnuts the cotton was sown in the middle of the furrows.

The results with cotton (Allen) were:—

	Seed cotton lb. per acre.	Odds that difference is significant.
Average yield of 5 plots following Mucuna	95	—
Average difference of 4 plots with Ground-nuts	— 24·5±12·76	34 : 1

Maize was sown throughout these plots this season to further test the effects of the mucuna and groundnuts. As the outside plots yielded much less than the others they have been discarded.

For Defects *see* Table X.

The results with maize are as follows:—

	Dry grain lb. per acre.	Odds that difference is significant.
Average yield of 4 plots following Ground-Nuts	993	—
Average difference of 3 plots following Mucuna	+186±64·5	390 : 1

The results indicate that following mucuna, the cotton crop immediately following, is slightly better than when following groundnuts. In the following season the maize crop is significantly better following mucuna than following groundnuts.

GREEN MANURING EXPERIMENT.

In 1923 various beans were grown to determine the most suitable for green manurial purposes.

Mucuna and dolichos were far superior to any in the amount of growth made during the season.

In 1924 and 1925 these two varieties were grown in alternate half acre plots on a ten acre block and the vegetative growth of each year turned in in March, 1925, and February, 1926, respectively.

In 1925 maize was sown in double rows on five feet ridges, stands two feet apart and two plants per stand. The result showed no significant difference between the two sets of plots as a result of the preceding crop of mucuna and dolichos. After the maize was harvested last year, mucuna made fairly good growth but dolichos was very backward throughout.

This season maize was sown in double rows on five feet ridges, stands two feet apart and one plant per stand.

FOR FURTHER DETAILS *see* TABLE XI.

The results are as follows:—

	Dry grain, lb. per acre.	Odd that difference is significant.
Average yield of 10 plots following Dolichos	1,057	—
Average difference of 9 plots following Mucuna	−136±77·3	24 : 1

There is a small indication that dolichos is better than mucuna.

On June 11th mucuna and dolichos were sown through the maize in the same plots as last year.

Mucuna has produced much better growth than dolichos, though the latter continued its growth much longer into the dry season.

THIRTY ACRE, THREE YEARS ROTATION.

A special article is being written on this experiment so that it is unnecessary to deal with it here.,

THREE YEARS ROTATION EXPERIMENT.

The three sets of three years rotations, started in 1924, have now completed their first round. Next season when they have come back to the first year's crops, they will begin to assume very special interest. The yields will then be published.

EFFECT OF DIFFERENT CROPS ON THE SOIL.

To test the effects of different crops on the soil, using maize as test crop in following season.

The following crops were grown:—

Standard, Maize and Guinea corn, ten plots.

Yams, three plots.

Maize and Mucuna, three plots.

Groundnuts and Guinea corn, three plots.

The results are of no value until the test crop has been grown, and are therefore held over.

Limes.—The lime crop this season has been very low, as has all citrus fruits growing on the plantation. The limes were planted in 1915.

The yields for the last three years have been :—

	Plots 21–24. (1 acre)	Plots 25–28. (1 acre.)
1924 ...	26,234 lbs.	6,982 lbs.
1925 ...	34,200 „	23,362 „
1926 ...	14,531 „	17,742 „

Coconuts.—Acreage, one acre. Planted out 1918.

They have grown fairly well but up to date only three palms have shown signs of flowering.

Orchard.—There is a good collection of oranges and tangerines which have now commenced bearing. These were mostly produced from root suckers of lime trees which had been cut down, and budded from oranges originally obtained from Kaduna and the tangerines from a really good type from Bida.

GREEN MANURING ON WET RICE LAND.

The following were tried, but all failed to grow on the wet land :—

Mucuna;
Dolichos;
Pigeon peas;
Rere.

THOS. THORNTON.

TABLE GIVING RAINFALL.

1926.		1927.	
January	— inches.	January	—
February	1·03 „	February	·79 inches.
March	0·82 „	March	0·00 „
April	3·90 „		
May	7·71 „		
June	5·95 „		
July	6·77 „		
August	6·16 „		
September	11·38 „		
October	·93 „		
November	1·44 „		
December	„		
	48·09 inches.		

TABLE No. I.

Cotton Variety Test.

Plots.	Variety.	Yield per acre.	Compared with mean of adjacent plots.
Block B.			
8	Ilorin	284 lb.	
9	Kabba	252 „	— 75
10	Ilorin	370 „	
11	Ishan	336 „	— 19
12	Ilorin	341 „	
13	Kabba	208 „	— 196
14	Ilorin	476 „	
15	Ishan	386 „	— 41
16	Ilorin	379 „	
29	Ilorin	368 „	
30	Kabba	327 „	— 133
31	Ilorin	552 „	
32	Ishan	441 „	— 103
33	Ilorin	536 „	
34	Kabba	253 „	— 268
35	Ilorin	507 „	
36	Ishan	501 „	— 8
37	Ilorin	512 „	
38	Ishan	416 „	
39	Ishan	417 „	
40	Ishan	420 „	

Average of standards 432 lb. per acre.

Root — mean — square — difference 94 lb. per acre.

Increase (+) or decrease (−) of Kabba compared with Ilorin.	Increase (+) or decrease (−) of Ishan compared with Ilorin.
— 75	— 19
— 196	— 41
— 133	— 103
— 268	— 8
Average — 168±47 lb. per acre.	— 42±47 lb. per acre.

Size of plots = $\frac{1}{4}$ acre each.

Ridges = 6 feet apart.

Stands = $1\frac{1}{2}$ „ „ 2 plants per stand.

Time sowing = July 2nd.

Cost of cultivation = 85 man-days per acre.

TABLE No. II.

Cotton Variety Test through Yams. Variety Boki.

Plots.	Yams Variety.	Harvested per acre lb.	Cotton Variety.	Yield per acre lb.	Compared with mean of adjacent standards.
A. 1	Boki.	14,400	Ilorin	133	
2	,,	12,320	Kabba ...	132	+ 18
3	,,	11,040	Ilorin	95	
4	,,	10,720	Ishan	143	+ 3
5	,,	12,640	Ilorin	185	
6	,,	10,880	Kabba ...	152	+ 2
7	,,	8,182	Ilorin	116	
8	,,	11,120	Ishan	132	— 20
9	,,	13,440	Ilorin	189	
10	,,	12,992	Kabba ...	162	— 23
11	,,	15,904	Ilorin	182	
12	,,	15,908	Ishan	162	— 31
13	,,	14,896	Ilorin	205	
14	,,	15,232	Kabba ...	183	— 38
15	,,	16,352	Ilorin	238	
16	,,	18,592	Ishan	135	— 60
17	,,	16,464	Ilorin	153	
18	,,	17,536	Ishan	164	
19	,,	18,032	,, ...	182	
20	,,	18,368	,, ...	171	

Average of standards 166 lb. per acre.

Root — mean — square — difference 59 lb. per acre.

Increase (+) or decrease (—) of Kabba compared with Ilorin.	Increase (+) or decrease (—) of Ishan compared with Ilorin.
+ 18	+ 3
+ 2	— 20
— 23	— 31
— 38	— 60
Average — 10 ± 29 lb per acre.	Average — 27 ± 29 lb per acre.

Size of plots = $\frac{1}{4}$ acre each.

Ridges = 6 ft. apart.

Stands = $1\frac{1}{2}$ ft. ,, 2 plants a stand.

Date of sowing, July 1st.

Cost of cultivation, A and C1 — 20 = 26·3 man-days per acre.

TABLE No. III.

COTTON VARIETY TEST THROUGH YAMS.

Plots.	Yams.	Yield per acre lb.	Cotton.	Yield per acre lb.	Increase (+) or decrease (—) compared with mean of adjacent controls.
Block C					
1	Boki	13,328	Ilorin ...	114	
2	White Lisbon ...	9,408	Kabba ...	118	— 3
3	Boki	15,008	Ilorin ...	129	
4	Pansaga ...	9,408	Ishan ...	190	+ 42
5	Boki	15,680	Ilorin ...	168	
6	White Lisbon ...	14,336	Kabba ...	126	— 25
7	Boki	15,456	Ilorin ...	135	
8	Pansaga ...	8,064	Ishan ...	163	+ 40
9	Boki	15,232	Ilorin ...	112	
10	„	12,544	Kabba ...	62	— 57
11	„	12,992	Ilorin ...	126	
12	„	16,464	Ishan ...	128	+ 1
13	White Lisbon ...	12,992	Ilorin ...	128	
14	Boki	15,232	Kabba ...	121	— 77
15	Pansaga ...	8,960	Ilorin ...	268	
16	Boki	15,904	Ishan ...	125	— 81
17	White Lisbon ...	11,648	Ilorin ...	145	
18	Boki	15,232	Kabba ...	147	— 26
19	Pansaga ...	7,392	Ilorin ...	201	
20	Boki	15,680	Ishan ...	166	

Average of standards 152 lb. per acre.

Root—mean—square—difference = 68 lb. per acre.

Increase (+) or decrease (—) of Kabba compared with Ilorin.	Increase (+) or decrease (—) of Ishan compared with Ilorin.
— 3	+ 12
— 25	+ 40
— 57	+ 1
— 77	— 81
— 26	

Average — 38 ± 30 lb. per acre. Average + 1 ± 34 lb. per acre.

Size of plots = $\frac{1}{4}$ acre each.
Ridges = 6 ft. apart.
Stands = $1\frac{1}{2}$ „ „
Time of sowing = July 1st.

Cost of cultivation, A and C 1–20 = 26·3 man-days per acre.

TABLE No. IV.

TIME OF SOWING TEST. KABBA COTTON.

Plots.	Time of sowing.	Yield per acre.	Compared with average of adjacent Standards
E. 29	July 1st	153	
30	June 1st	189	+ 41
31	July 1st	144	
32	June 15th	178	+ 27
33	July 1st	158	
34	July 15th	110	— 41
35	July 1st	145	
36	June 1st	194	+ 48
37	July 1st	147	
38	June 15th	182	+ 31
39	July 1st	155	
40	July 15th	114	— 39
41	July 1st	152	
42	June 1st	188	+ 54
43	July 1st	116	
44	June 15th	160	+ 6
45	July 1st	192	
46	July 15th	120	— 70
47	July 1st	189	
F. 33	July 1st	243	
34	June 1st	217	— 39
35	July 1st	209	
36	June 15th	243	— 11
37	July 1st	239	
38	July 15th	176	— 91
39	July 1st	296	

Average of standards = 185 lb. per acre.

Root—mean—square—difference = 32 lb. per acre.

Increase (+) or decrease (−) of June 1st compared with July 1st.	Increase (+) or decrease (−) of June 15th compared with July 1st.	Increase (+) or decrease (−) of July 15th compared with July 1st.
+ 41	+ 27	— 41
+ 48	+ 31	— 39
+ 54	+ 6	— 70
— 39	— 11	— 91
Average + 26 ± 16 lb. per acre.	Average + 13 ± 16 lb. per acre.	Average — 60 ± 16 lb. per acre.

Size of plots = $\frac{1}{4}$ acre each.

Ridges = 6 ft. apart.

Stands = $1\frac{1}{2}$ „ „ mostly 2 plants to a stand.

Cost of cultivation = 63 man-days per acre.

TABLE No. V.

Kabba Cotton with Groundnuts *v.* Cotton without Nuts.

Plots.	Groundnuts per acre lb.	Seed cotton per acre lb.	Compared with average of standards.
F. 26	1,588	173	
27		233	+ 74
28	1,768	146	
29		298	+ 135
30	1,816	181	
31		282	+ 104
32	1,648	175	

Average of standards 168 lb. seed cotton —1,705 lb. groundnuts per acre.

Root—mean—square—difference = 25 lb. seed cotton per acre.

Cotton grown alone compared with cotton grown with groundnuts.
+ 74
+ 135
+ 104

Average ... ... + 104 ± 14·4 lb. per acre.

Size of plots = $\frac{1}{4}$ acre each.

Ridges = 6 ft. apart.

Stands = cotton $1\frac{1}{2}$ ft. apart, 2 plants to a stand.

Groundnuts — in double rows.

Time of sowing. Cotton with groundnuts, June 1st.

,, alone, July 1st.

Cost of cultivation.

Combined cost. Cotton with groundnuts = 166 man-days per acre.

,, alone = 62 per acre.

TABLE No. VI.

Ground Nuts Variety Test.

Plots.	Variety.	Unshelled dry nuts per plot lb.	Unshelled dry nuts per acre lb.	Increase (+) or decrease (−) compared with mean of adjacent standards.
Block G				
21	Ilorin No. 2	324	1,296	
22	Zaria	281	1,124	− 196
23	Ilorin No. 2	336	1,344	
24	Gambia	330	1,320	− 6
25	Ilorin No. 2	327	1,308	
26	Chinese	298	1,192	− 58
27	Ilorin No. 2	298	1,192	
28	Zaria	248	992	− 82
29	Ilorin No. 2	239	956	
30	Gambia	238	952	+ 82
31	Ilorin No. 2	196	784	
32	Chinese	232	928	+ 76
33	Ilorin No. 2	230	920	
34	Zaria	219	876	− 64
35	Ilorin No. 2	240	960	
36	Gambia	218	872	− 116
37	Ilorin No. 2	254	1,016	
38	Chinese	258	1,032	− 6
39	Ilorin No. 2	265	1,060	
40	Zaria	248	992	− 42
41	Ilorin No. 2	252	1,008	
42	Gambia	230	920	− 68
43	Ilorin No. 2	242	968	
44	Chinese	211	844	− 74
45	Ilorin No. 2	217	868	

Increase (+) or decrease (−) of Zaria compared with Ilorin No. 2.	Increase (+) or decrease (−) of Gambia compared with Ilorin No. 2.	Increase (+) or decrease (−) of Chinese compared with Ilorin No. 2.
−196	− 6	− 58
− 82	+ 82	+ 76
− 64	−116	− 6
− 42	− 68	− 74
Average −96±54·5 lb. per acre.	−27±54·5 lb. per acre.	−15·5±54·5 lb. per acre.

Root—mean—square—difference = 109 lb. per acre.
Average yield per acre of control plots = 1,052 lb. dry unshelled nuts.
Size of plots $\frac{1}{4}$ acre.
Seed sown April 19th. Reaped September 10th–15th.
Cost of Cultivation = 87 man-days per acre.

TABLE No. VII.

Ground Nut Spacing Test.

Variety : *Ilorin No. 2.*

Plots.	Spacing.	Unshelled dry nuts per plot in lb.	Unshelled dry nuts per acre in lb.	Increase (+) or decrease (−) compared with mean of adjacent standards.
Block G				
46	6 inches	215	860	
47	12 „	298	1,192	+ 272
48	6 „	245	980	
49	18 „	239	956	+ 12
50	6 „	227	908	
51	12 „	253	1,012	+ 70
52	6 „	244	976	
53	18 „	281	1,124	+ 94
54	6 „	271	1,084	
55	12 „	271	1,084	+ 28
56	6 „	257	1,028	
57	18 „	272	1,088	+ 26
58	6 „	274	1,096	
59	6 „ N.E.	231	924	
60	6 „ N.E.	260	1,024	

Increase (+) or decrease (−) of 12″ spacing compared with 6″.	Increase (+) or decrease (−) of 18″ spacing compared with 6″.
+ 272	+ 12
+ 70	+ 94
+ 28	+ 26
Average + 123±49·1 lb. per acre.	Average + 44±49·1 lb per acre.

Root—mean—square—difference = 85 lb. per acre.

Average yield per acre of control plots = 990 lb. dry unshelled nuts.

Size of plots $\frac{1}{4}$ acre.

Seed sown April 19th and 20th. Reaped September 20th and 21st

Cost of cultivation = 89 man-days per acre.

TABLE No. VIII.

YAM VARIETY TEST.

Plots.	Variety.	Returns per acre in lb.	Increase (+) or decrease (−) compared with mean of adjacent standards
Block C			
1	Boki	13,328	
2	White Lisbon	9,408	— 4,760
3	Boki	15,008	
4	Pansaga	9,408	— 5,936
5	Boki	15,680	
6	White Lisbon	14,336	— 1,232
7	Boki	15,456	
8	Pansaga	8,064	— 7,280
9	Boki	15,232	
10			
11			
12	Boki	16,464	
13	White Lisbon	12,992	— 2,856
14	Boki	15,232	
15	Pansaga	8,960	— 6,608
16	Boki	15,904	
17	White Lisbon	11,648	— 3,920
18	Boki	15,232	
19	Pansaga	7,392	— 8,064
20	Boki	15,680	

Size of plots $\frac{1}{4}$ acre. Ridges 6 feet apart. Stands $2\frac{1}{2}$ feet apart.

Cotton was grown throughout between the ridges.

Increase (+) or decrease (−) of White Lisbon as compared with Boki.	Increase (+) or decrease (−) of Pansaga as compared with Boki.
— 4,760	— 5,936
— 1,232	— 7,280
— 2,856	— 6,608
— 3,920	— 8,064

Average — 3,192±433 lb per acre. Average — 6,972±433lb. per acre.

Root—mean—square—difference=866 lb. per acre.

Average of Standards per acre=15,321 lb.

Cost of cultivation=111 man-days per acre A and C 1–20.

TABLE No. IX.

Maize Spacing Test with Guinea Corn.

Combined Results.

Plots.	Maize Spacing.	Maize returns grain per acre.	Guinea Corn returns grains per acre.	Maize and Guinea Corn.	Increase (+) or Decrease (−) compared with mean of adjacent controls.
Block A.					
21	2′ × 5′	1,000	488	1,488	
22	1½′ × 5′	1,348	456	1,804	+ 272
23	2′ × 5′	1,116	460	1,576	
24	1′ × 5′	1,060	232	1,292	− 504
25	2′ × 5′	1,348	668	2,016	
26	1′ × 2½′	1,720	228	1,948	− 272
27	2′ × 5′	1,612	812	2,424	
28	1½′ × 5′	1,660	772	2,432	+ 58
29	2′ × 5′	1,508	816	2,324	
30	1′ × 5′	1,512	564	2,076	− 306
31	2′ × 5′	1,564	876	2,440	
32	1′ × 2½′	1,676	304	1,970	− 320
33	2′ × 5′	1,424	716	2,140	
34	1½′ × 5′	1,316	704	2,020	− 86
35	2′ × 5′	1,392	680	2,072	
36	1′ × 5′	1,372	592	1,964	182
37	2′ × 5′	1,436	784	2,220	
38	1′ × 2½′	1,952	328	2,280	− 52
39	2′ × 5′	1,456	780	2,236	
40	2′ × 5′	1,516	772	2,288	

Each plot ¼ acre. Ridges 5 ft. apart.

Maize sown 26th April, 1926. Harvested 17th August, 1926.

Guinea Corn sown 25th May, 1926. Harvested 17th December, 1926.

Guinea Corn stands 2 ft. apart.

Increase (+) or Decrease (−) of 1½ ft. spacing of Maize as compared with 2 ft.	Increase (+) or Decrease (−) of 1 ft. spacing of Maize as compared with 2 ft.	Increase (+) or Decrease (−) of 1 ft. spacing of Maize in double rows as compared with 2 ft.
+ 272	− 504	− 272
+ 58	− 306	− 320
− 86	− 182	− 52
Average + 81 ± 137 lb. per acre.	− 330 ± 137 lb. per acre.	− 214 ± 137 lb. per acre.

Root—mean—square—difference = 238 lb. per acre.

Average of control plots = 2,093 lb. per acre.

Cost of cultivation = 80 man-days per acre.

TABLE No. X.

1925–26. MUCUNA AND ALLEN COTTON *v.* GROUNDNUTS AND ALLEN COTTON.

1926–27. TEST CROP MAIZE.

Plots.		1925–26.	1926. Maize lb. per acre.	Increase (+) or Decrease (−) compared with mean of adjacent controls.
E2.	1	Mucuna and Cotton	924	
	2	Groundnuts and Cotton ...	1,024	
	3	Mucuna and Cotton	1,140	+ 186
	4	Groundnuts and Cotton ...	884	
	5	Mucuna and Cotton	1,128	+ 188
	6	Groundnuts and Cotton ...	996	
	7	Mucuna and Cotton	1,216	+ 184
	8	Groundnuts and Cotton ...	1,068	
	9	Mucuna and Cotton	832	

Plots 1 and 9 appear to be unduly low and have been discarded in the calculations.

Increase (+) or decrease (−) after Mucuna compared with after groundnuts.

+ 186

+ 188

+ 184

Average + 186 ± 65 lb. per acre.

Average of Standards = 993 lb. per acre.

Root—mean—square—difference = 112 lb. per acre.

TABLE No. XI.

Maize following Mucuna and Dolichos.

Plots.	Preceding crop.	Dry grain per plot lb.	Dry grain per acre lb.	Increase (+) or decrease (−) of Maize following Mucuna compared with Maize following Dolichos.
Block A.				
62	Dolichos ...	779	1,558	
64	Mucuna ...	671	1,342	− 62
66	Dolichos ...	625	1,250	
68	Mucuna ...	627	1,254	− 129
70	Dolichos ...	758	1,516	
72	Mucuna ...	450	900	− 623
74	Dolichos ...	765	1,530	
76	Mucuna ...	555	1,110	− 298
78	Dolichos ...	643	1,286	
80	Mucuna ...	570	1,140	+ 81
82	Dolichos ...	416	832	
84	Mucuna ...	364	728	− 76
86	Dolichos ...	388	776	
88	Mucuna ...	305	610	− 64
90	Dolichos ...	286	572	
92	Mucuna ...	286	572	− 37
94	Dolichos ...	323	646	
96	Mucuna ...	303	606	− 19
98	Dolichos ...	302	604	
100	Mucuna N.E.	324	648	

Increase (+) or decrease (−) of Maize following Mucuna compared with Maize following Dolichos.
− 62
− 129
− 623
− 298
+ 81
− 76
− 64
− 37
- 19
Average − 136.3 ± 77·3 lb. per acre.

Root–mean–square–difference = 232 lb. per acre.

Average yield per acre of control plots = 1,057 lb. dry grain.

Size of plots ½ acre.

Maize sown April 27th. Harvested August 23rd–25th.

Cost of cultivation = 48 man-days per acre, maize.

11 „ „ Mucuna and Dolichos.

Costs and Values of the Principal Crops, per Acre.

Crop.	Plots.	Acreage.	Returns per acre.	Price.	Value.	Cost.	Man-days per acre.	Value per man-day.
					£ s. d.	£ s. d.		
Cotton Variety Test through Yams	A, B 1–20	10	151 lb.	1d. per lb.	0 12 7	0 19 9	26·3	5·75d.
Cotton Variety Test grown alone	B 8–16, 29–40	5¼	394 lb.	1d. per lb.	1 12 10	3 4 0	85	4·6d.
Ground-nuts	G. 21–45	6¼	Kernels. 665 lb.	£11 per ton.	3 5 3	3 5 0	87	9d.
Yams	A, C 1–20	10	* 8118 lb.	80 lb. for 1s.	5 1 0	4 3 3	111	11d.
Maize and Guinea Corn.	A. 21–40	5	Maize 1,449 lb. G. Corn 601 lb.	£3 11s. 9d. ton. ¾d. per lb.	2 6 5 1 17 6	3 0 2	80	1s. 0½d.
Maize, Mucuna and Dolichos.	A 61–100	10	974 lb.	£3 11s. 9d. ton.	1 11 3	1 15 7 0 8 2	48 11	7·8d.
† Mucuna.	B, C 41–60	10	...	...	...	1 3 7	31·4	...

* Allowed 2,800 for planting. Allowed 25% 2,706 loss from drying and spoiling. Wages, 9d. per day.
† The land was ridged, this is unnecessary, therefore cost is high.

ANNUAL REPORT, SAMURU AGRICULTURAL STATION, ZARIA, NORTHERN PROVINCES, 1926.

Total area of station—724 acres.
Total area under cultivation 130.0 acres.
Latitude. 11° 12′ North.
Longitude. 7° 37′ East.
Altitude 2,200 feet (approximate).
Mean (Zaria) rainfall 1904-26 : 44.764 inches.
Distance from nearest point on the coast, 400 miles (approx.).

General Notes.

The results obtained from the year's working have been interesting because it has been possible to indicate the following points :—

(*a*) the failure of early green manuring;

(*b*) the superiority of stall-fed cattle as manure makers over cattle pastured in the bush during the day and tethered on farms at night;

(*c*) the possibility of growing a cheap fodder crop for cattle;

(*d*) the feasibility of feeding native bred calves by the pail.

Early Green Manuring.

Investigations in the past have found that of the various varieties of leguminous beans, mucuna makes a larger vegetative growth at the beginning of the season than any other. However, this growth is not sufficient to make the turning in of mucuna worth while prior to planting cotton. Mucuna beans, moreover, do not seem to make any headway at all until late June or early July no matter how early they are planted and they need constant attention and frequent supplying.

Pail-Fed Calves.

It has been the practice in the past to allow calves to suckle their dams until weaning and this method of rearing is carried out by the Fulani herdsmen.

It was found, however, in India, that by removing calves from the cow at birth and rearing them artificially the frequency of breeding was increased and an attempt has been made to start the hand rearing of calves here. This method is practically essential for any real stock breeding for improvement of milk cattle, as otherwise the milk records cannot be reliable.

Seven calves have been born during the year and each one has been removed from the cow at birth and fed by the pail. Except in the case of one which died four days after birth, its death being almost certainly due to the fact that it had been born prematurely, the calves have thrived and done extraordinarily well.

It is yet too early to say whether by removing and hand-feeding calves, the cows will calve more frequently; but all those which calved during the year are now in calf again.

Cultivation.

The rainfall in 1926 (Table No. 1) was greater than during the two preceding years, although it ceased in the first week in October. Exceptionally heavy rains were experienced during late June, July and August, which necessitated very careful handling of the Samuru Farm, patches of cotton were completely submerged and every crop on the farm suffered to some extent from waterlogging.

The damage caused by waterlogging on this farm seems to be increasing year by year and the greatest care will be required in dealing with this difficulty in the future.

Cropping Notes.

Bullrush millet (Gero).

It was decided to plant this crop on the sides of the ridges this year as opposed to sowing it in furrows as previously and it seems to have been a success as the gero crop on the farm was better than it has been for two years, although the fact must not be overlooked that it was a good gero year in the district. Where it was planted with Guinea corn and cowpeas the average yield was 473 lb. per acre. Where interplanted with mucuna the average yield was 591 lb. per acre. After the gero harvest the mucuna did very well producing over a ton of mucuna hay to the acre. This fact is particularly pleasing as it shows the possibility of growing a cheap fodder crop for cattle and if the mucuna is made hay of at the earliest opportunity (*i.e.*, late September or early October), and ratooned at the same time, there is a possibility of a further supply of fodder or green manure being available.

Guinea Corn (Dawa).

The yellow-seeded variety (Kaura) on the farm did better than in the district around, yielding up to 1,492 lb. per acre and the average for the whole farm was 960 lb. per acre. The white-seeded variety (Farafara) was poor. It was on the whole a poor year for dawa owing to the early cessation of the rains, and none of the yields was up to the standard of two years ago.

Cowpeas (Wake).

A failure this year as everywhere in the Samuru district. The highest yield of unshelled beans was only 188 lb. per acre.

Groundnuts.

The crop promised to be a very good one but suffered from being waterlogged and the yields at harvesting time were disappointing. The local spreading variety yielded on an average 720 lb. unshelled nuts per acre which was slightly better than last year.

Cotton.

Except in the Strain Test Maigana Strain I was sown throughout the farm and one plant left to a stand.

The yields were distinctly poor, the highest yield per acre on unmanured land being 516 lb. per acre whilst the average over the whole farm was under 200 lb. per acre. Owing to the rains ceasing early the first picking was very clean and bright.

Cover Crops.—Mucuna has proved a failure when interplanted with dawa and cotton but with gero, as mentioned above, and by itself has given a large yield of foliage.

Ratooned mucuna and late sown (September) has withstood the dry season well, although the amount of foliage produced has not been very great. Varieties of mucuna from Nyasaland have been particularly good in this respect.

The white variety of Lima bean brought from Nyasaland has yielded better than the native cowpea and is being adopted next year on the farm in its place.

Early Green Manuring Experiment.

Table No. 2.

This experiment was repeated from last year, as apart from the results not being conclusive, the main object is to see to what degree fertility can be maintained by perpetual early green manuring.

	Yield of seed cotton in lb. per acre.	Odds that difference is significant.
Average yield 7 plots without early green	439	
Average difference 6 plots early green manured	− 28 ± 66	—

Exhaustibility of Crops Experiment.

(Tables Nos. 3, 3a, 4 and 4a.)

This experiment was started in 1924 and in that year all the plots were sown with mucuna beans and the foliage turned in to give an even dressing per acre.

The object was to discover to what degree the following crops exhausted the soil, *viz.*, groundnuts, Guinea corn, cotton and maize and these were sown and harvested in 1925.

On plots 14-26 the testing crop was cotton and on plots 27-39 Guinea corn.

Block A 14—26	Yield of seed cotton in lb. per acre.	Odds that difference is significant.
Average yield of cotton on 7 plots following groundnuts	291	—
Average difference of cotton yields on 2 plots following maize	− 25 ∓ 69	—
Average difference of cotton yields on 2 plots following guinea corn	+ 15 ∓ 69	—
Average difference of cotton yields on 2 plots following cotton	− 15 ∓ 69	—

Block A 27– 39	Yield of Guinea corn heads in lb. per acre.	Odds that diffence is significant.
Average yield of guinea corn on 7 plots following groundnuts	1,044	—
Average difference of guinea corn yields on 2 plots following maize	− 278 ∓ 300	5 : 1
Average difference of guinea corn yields on 2 plots following guinea corn ...	− 301 ∓ 300	5 : 1
Average difference of guinea corn yields on 2 plots following cotton	− 50 ∓ 300	—

The variability of the soil, as shown by the yields of the control plots (groundnuts) in 1925, is considerable and the value of the experiment is reduced in consequence. Yet, allowing for this, the results indicate that Guinea corn shows up the exhaustion by the previous crops much more than does cotton, and the experiment indicates the advantage of groundnuts and cotton as rotational crops.

GROUNDNUT VARIETY TEST.

Table No. 5.

	Yield unshelled nuts in lb. per acre.	Odds that difference is significant.
Average yield 16 plots under Zaria variety	720	—
Average difference 3 plots under American variety	− 58 ± 63	5 : 1
Average difference 3 plots under Chinese variety	+ 54 ± 63	5 : 1
Average difference 3 plots under Gambia variety	− 12 ± 63	—
Average difference 3 plots under Ilorin 2 variety	+ 50 ± 63	5 : 1
Average difference 3 plots under Kano variety	− 19 ± 63	—

All the plants suffered from waterlogging except in the extreme northern end of the block where the yields were nearly 1,000 lb. per acre. The presence of surplus water was very noticeable.

This was the third year in which this experiment has been carried out. Whether the yields of various varieties are seriously affected by years of heavy and low rainfall, it is not possible to say definitely but the result of this year and last year would seem to indicate this, as they in no way agree. In 1925 the rains carried on until late November and in 1926 there was only one rain after the end of September, of 1.5 inches.

ORDER OF HIGH YIELDS.

1924.		1925.		1926.	
1. Gambia	+159 ± 123	1. Kano	+41 ± 60	1. Chinese	+54 ± 63
2. Kano	+ 61 ± 123	2. American	+29 ± 60	2. Ilorin 2	+50 ± 63
3. Ilorin (2)	+ 37 ± 123	3. Zaria		3. Zaria	
4. Zaria		4. Gambia	−18 ± 60	4. Gambia	−12 ± 63
5. Chinese	− 32 ± 123	5. Ilorin II	−65 ± 60	5. Kano	−19 ± 63
6. American	− 67 ± 123	6. Chinese	−111 ± 60	6. American	−58 ± 63

DATE OF PLANTING COWPEA TEST.

Table No. 6.

	Yields of threshed beans in lb. per acre.	Odds that the difference is significant.
Average of 17 plots, planted August 1st.	25	—
Average of 8 plots, planted July 15th	+ 2·2 ± 5·4	—
Average of 8 plots, planted August 15th	−13·1 ± 5·4	43 : 1

The deplorable low yield recorded is attributable to the season but the result shows the advisability of planting early.

FARMYARD MANURE *versus* KRAALING EXPERIMENT.—TABLE NO. 7.

In the past when it was necessary to apply cattle manure to the farm it was done by tethering cattle, which had been pastured in the bush during the daytime, on the farm at night (*i.e.*, Kraaling).

When the making of manure in the yard was started, it was thought that some knowledge should be obtained as to the relative values of " kraaled " and yard manure.

To do this the above experiment was carried out on the following lines :—

Cattle were pastured in the bush during the day and put into an open yard at night receiving bedding at the rate of eight pounds (weight) per head per night and records of the number of the nights and number of cattle were kept. When the grass in the bush was scarce the cattle were fed on mucuna bean straw. When enough manure had been made it was dug out of the yard and weighed.

It was decided to test the value of manure made by cattle kraaled on the land at the rate of 400 cattle-nights per acre against manure made in one night by 400, 300, 200 and 100 stall-fed cattle respectively, the calculated equivalent weights of farmyard manure being applied by hand.

	Yield of seed cotton in lb. per acre.	Odds that the difference is significant.
Average of 17 plots, manured with 400 cattle-nights Kraaled per acre	264	—
Average of 4 plots, manured with 400 cattle-nights, F.Y.M. per acre	+ 80±27	740 : 1
Average of 4 plots, manured with 300 cattle-nights F.Y.M. per acre	+ 35±27	14 : 1
Average of 4 plots, manured with 200 cattle-nights F.Y.M. per acre	+ 13.5±27	—
Average of 4 plots, manured with 100 cattle-nights F.Y.M. per acre	− 7.5±27	—

The reliability of the present test was affected slightly by rain when the yard manure was being weighed and apportioned to the plots.

One hundred cattle nights farm yard manure and 200 cattle nights farm yard manure gave yields differing little from those produced by 400 cattle nights kraaled on the land. Three hundred cattle nights farm yard manure gave a somewhat better yield and 400 cattle nights farm yard manure a much greater increase. In the 1927 season the whole field is being tested by a further crop, guinea corn, of which the yields will support or modify the above conclusions.

MANURING EXPERIMENT—NIGERIAN ROCK PHOSPHATE AND FARMYARD MANURE.

Table No. 8.

1926 was the last year of this experiment and groundnuts were sown throughout both blocks. Germination was poor. A heavy rainfall of 2·95 inches on the night of June 26th washed out one plot and heavy supplying was necessary generally.

	Yield of dry unshelled nuts in lb. per acre.	Odds that the difference is significant.
A. Block (Y)		
Average yield of groundnuts on 7 plots unmanured	316	—
Average yield of groundnuts on 2 plots manured with F.Y.M. and phosphate ...	+289±69	> 33,300 : 1
Average yield of groundnuts on 2 plots manured with phosphate alone ...	+237±69	4,350 : 1
Average yield of groundnuts on 2 plots manured with F.Y.M. alone	+ 94±69	14 : 1
B. Block (Z)		
Average yield of groundnuts on 7 plots unmanured	316	—
Average yield of groundnuts on 2 plots manured with F.Y.M. and phosphate ...	+435±89	> 33,300 : 1
Average yield of groundnuts on 2 plots manured with phosphate alone... ...	+292±89	4,350 : 1
Average yield of groundnuts on 2 plots manured with F.Y.M. alone	+325±89	4,350 : 1

Farmyard manure and phosphate combined have given the greatest yield per acre in both blocks. The results from the plots manured with farmyard manure and phosphate alone in the two blocks are conflicting and this might be attributed to the washout in plot 12, Block Y, a plot manured with farmyard manure.

Further experimental work on artificial and farmyard manures is being carried out in the coming year.

For previous results in this experiment *see* page 196 Bulletin, 1925, page 122 Bulletin, 1926. The following is a correction of certain errors appearing in the 1926 Bulletin.

Error in 1926 Bulletin.

In working the results of the Nigerian Rock Phosphate and Cattle Manure experiment an error was made in Block Y, owing to the plan which was used for working out the results after the fire having the plots on this block incorrectly numbered.

The necessary corrections are herewith given, also including all other portions of the Bulletin in bearing on the result, in order

to make the corrected experiment appear as a composite whole.

1926 Bulletin, pages 122-123.

Nigerian Rock Phosphate and Cattle Manure Experiment.

This experiment was designed to test the manurial value of Nigerian Rock Phosphate both alone and in combination with farmyard manure, and the complete year to year cropping of Block Y was as follows, each plot being 1/13 acre :—

First year	...	Cotton	...	Sown uniformly without manure to test uniformity of soil.
Second year	...	Cover Crop	...	(Dolichos) dug in.
Third year	...	Maize	...	Cotton, Cowpeas.
Fourth year	...	Groundnuts	...	

Block Y — Maize. *See* Table No. 5.

	Yield of dry threshed maize in lb. per acre.	Odds that the difference is significant.
Average yield of maize on 7 untreated plots	116	
Average difference, maize on 2 plots F.Y.M. and phosphate	+413±93	100,100
Average difference, maize on 2 plots, phosphate	+202±93	65 : 1
Average difference maize on 2 plots F.Y.M.	+264±93	450 : 1

Block Y — Cotton. *See* Table No. 6.

	Yield of seed cotton in lb. per acre.	Odds that the difference is significant.
Average yield of Cotton from seven untreated plots	29·4	—
Average difference cotton from 2 plots F.Y.M. and phosphate	+ 51±10	∞ : 1
Average difference cotton from 2 plots phosphate	+ 12±10	7 : 1
Average difference cotton from 2 plots F.Y.M.	+ 47±10	∞ : 1

Block Y — Cowpeas. *See* Table No. 7.

	Yield of cowpeas (dry threshed beans) in lb. per acre.	Odds that the difference is significant.
Average yield of cowpeas on 7 untreated plots	9·7	—
Average difference cowpeas on 2 plots, F.Y.M. and phosphate	+ 18±3·5	∞ : 1
Average difference cowpeas on 2 plots, phosphate	+ 36±3·5	∞ : 1
Average difference cowpeas on 2 plots, F.Y.M.	+ 15±3·5	700,000 : 1

It is seen that in the case of maize and cotton farmyard manure and phosphate have given the highest yield, with farmyard manure alone a little way behind, but that phosphate alone has not given anything like so great an increase.

1926 Bulletin, pp. 131, 132 and 133.

TABLE No. 5.—1926 BULLETIN.

Manurial Experiment.

Maize—Nigerian Rock Phosphate and Cattle Manure.

No. of plot.	Treatment.	Yield in lb. of dry threshed maize per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
Block Y.			
Plot 1	No Manure	108 lb. per acre	
„ 2	$N_2+P_2O_5$	426 „ „	+ 234
„ 3	No Manure	276 „ „	
„ 4	P_2O_5	458 „ „	+ 163
„ 5	No Manure	314 „ „	
„ 6	N_2	630 „ „	+ 453
„ 7	No Manure	40 „ „	
„ 8	$N_2+P_2O_5$	636 „ „	+ 592
„ 9	No Manure	42 „ „	
„ 10	P_2O_5	242 „ „	+ 210
„ 11	No Manure	16 „ „	
„ 12	N_2	88 „ „	+ 76
„ 13	No Manure	8 „ „	

Plots 1/13 acre. Ridges 4′ apart. Stands 1′ apart.

Planted—June 1st, 1925. *Harvested*—October 15th, 1925.

Increase (+) or decrease (−) between plots manured with $N_2 + P_2O_5$ and unmanured plots.

+ 234 lb. per acre.
+ 592 „ „ „

Average + 413±93 lb. per acre.

Increase (+) or decrease (−) between plots manured with P_2O_5 and unmanured plots.

+ 163 lb. per acre.
+ 242 „ „ „

Average + 202±93 lb. per acre.

Increase (+) or decrease (−) between plots manured with N_2 and unmanured plots.

+ 453 lb. per acre.
+ 76 „ „ „

Average + 264±93 lb. per acre.

Root—mean—square—difference between neighbouring controls, 132 lb per acre.

Cost of cultivation in man-days per acre = 64.

TABLE No. 6.—1926 BULLETIN.

Manurial Experiment.

Cotton—Nigerian Rock Phosphate and Cattle Manure.

No. of Plot.	Treatment.	Yield in lb. of seed cotton per acre.	Increase (+) or Decrease (−) compared with mean of adjacent controls.
Block Y.			
Plot 1	No Manure	40 lb. per acre	
„ 2	$N_2+P_2O_5$	104 „ „	+ 58
„ 3	No Manure	52 „ „	
„ 4	P_2O_5	58 „ „	+ 12
„ 5	No Manure	40 „ „	
„ 6	N_2	52 „ „	+ 25
„ 7	No Manure	14 „ „	
„ 8	$N_2+P_2O_5$	56 „ „	+ 44
„ 9	No Manure	14 „ „	
„ 10	P_2O_5	32 „ „	+ 12
„ 11	No Manure	26 „ „	
„ 12	N_2	92 „ „	+ 69
„ 13	No Manure	20 „ „	

Plots 1/13 acre. Ridges 4′ apart. Single Stands 12″ apart.

Planted—July 8th, 1925. *Picked*—January 19th – February 18th, 1926.

Increase (+) or decrease (−) between plots manured with $N_2+P_2O_5$ and unmanured plots.	Increase (+) or decrease (−) between plots manured with P_2O_5 and unmanured plots.	Increase (+) or decrease (−) between plots manured with N_2 and unmanured plots.
+ 58 lb. per acre	+ 12 lb. per acre	+ 25 lb. per acre
+ 44 „ „ „	+ 12 „ „ „	+ 69 „ „ „
Average + 51 ± 10 lb. per acre.	Average + 12 ± 10 lb. per acre.	Average + 47 ± 10 lb. per acre.

Root—mean—square—difference between neighbouring controls. 14 lb. per acre.

Cost of cultivation in man-days per acre = 49.

TABLE No. 7.—1926 BULLETIN.

Manurial Experiment—Nigerian Rock Phosphate and Cattle Manure.

Wake—(Cowpeas).

No. of plots.	Treatment.	Yield of dry beans in lb. per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
Block Y.			
Plot 1	No Manure	8 lb. per acre.	
2	$N_2+P_2O_5$	32 „ „	+ 20
3	No Manure	16 „ „	
4	P_2O_5	88 „ „	+ 72
5	No Manure	16 „ „	
6	N_2	32 „ „	+ 20
7	No Manure	8 „ „	
8	$N_2+P_2O_5$	24 „ „	+ 16
9	No Manure	8 „ „	
10	P_2O_5	8 „ „	—
11	No Manure	8 „ „	
12	N_2	16 „ „	+ 10
13	No Manure	4 „ „	

Each plot $\frac{1}{73}$ acre. Ridges 4′ apart. Stands 5′ apart.

Planted, September, 1925. Harvested, December 22nd, 1925.

Increase (+) or decrease (−) between plots manured with $N_2+P_2O_5$ and unmanured plots.	Increase (+) or decrease (−) between plots manured with P_2O_5 and unmanured plots.	Increase (+) or decrease (−) between plots manured with N_2 and unmanured plots.
+ 20 lb. per acre.	+ 72 lb. per acre.	+ 20 lb. per acre.
+ 16 „ „ „	— „ „ „	+ 10 „ „ „
Average + 18 ±3·5 lb. p.a.	Average + 36 ±3·5 lb. p.a.	Average + 15 ±3·5 lb p.a.

Root—mean—square—difference of neighbouring control plots. 5 lb per acre.

Cost of cultivation in man-days per acre = 6.

(N.B. End of correction of errors).

Poultry.

Pens of pure bred Rhode Island Red, Light Sussex and Indian Game have been kept as in previous years and chickens were reared during the year.

Fourteen cockerels have been sold and nineteen pullets, 1,924 eggs have been sold and 287 set, making a grand total of 2,211 produced.

Chicken-pox was prevalent among the young stock in August but otherwise the stock has been healthy. They have shown a great improvement since the beginning of September as more attention has been paid to the feeding and general management and egg production has proportionately increased.

Cattle.

There are now thirty cattle on the farm, seven working oxen, three yearling bullocks, thirteen cows in calf, six calves and one barren cow. All are cross-breds mostly of the Shuwa type and were obtained in the first place merely as manure makers.

It is hoped that it will be possible to demonstrate a system of mixed farming in the future as the prevalence of rinderpest in the past which disease is now being controlled by the Veterinary Department with a system of provincial inoculation has militated hitherto against the introduction of cattle ploughing.

O. S. SWAINSON,
Superintendent.

for R. B. Shorter,
Superintendent of Agriculture.

(Drafted by Mr. R. B. Shorter.)

TABLE No. I.

Rainfall Record—Samuru 1926.

Month.	Inches of Rain recorded.	Number of days on which rain fell.	Average monthly rainfall at Samuru 1924–26 (inclusive).	Average monthly rainfall in Zaria 1904–26 (inclusive).
January ...	...	...	...	·002
February ...	...	...	...	·022
March ...	...	...	·797	·154
April ...	0·42	3	·983	1·759
May ...	3·66	10	3·090	4·340
June ...	9·29	10	7·500	6·335
July	13·10	18	12·390	9·170
August ...	12·90	19	11·470	12·170
September...	6·55	12	7·386	9·255
October ...	1·50	1	2·326	1·463
November ...	...	...	·133	·029
December ...	...	...	...	·065
Totals ...	47·42″	73	46·075	44·764

TABLE No. 2.

Cotton—Early Green Manuring Experiment.

Variety—Allen—Maigana No. 1.

No. of Plot.	Treatment.	Yields of Seed Cotton in lb. per acre.		Increase(+) or decrease(−) compared with mean of adjacent controls.
Block A				
Plot 1	No Green Manure	328		
„ 2	Early Green Manure		408	− 6
„ 3	No Green Manure	500		
„ 4	Early Green Manure		472	− 20
„ 5	No Green Manure	484		
„ 6	Early Green Manure		348	− 104
„ 7	No Green Manure	420		
„ 8	Early Green Manure		444	− 24
„ 9	No Green Manure	516		
„ 10	Early Green Manure		448	− 34
„ 11	No Green Manure	448		
„ 12	Early Green Manure		436	+ 22
„ 13	No Green Manure	380		

Each plot ¼ acre. Ridges 4′ apart. Stands of single plants 15″ apart.

Cotton—Sown—3rd July, 1926. Picked.—December 13th, 1926.
January 1st, 1927.
January 15th, 1927.
February 2nd, 1927.

Mucuna—Sown—1st May, 1926. Turned in July 2nd, 1926.

Cost of cultivation in man days per acre — 118.

Cotton alone — 100 man-days per acre.

Increase (+) or decrease (−) of Plots following Mucuna as compared with plots with no early Green manure.

− 6
− 20
− 104
− 24
− 34
+ 22

Average. -28 ∓ 66 lb. per acre.

Root—mean—square- difference between neighbouring control plots 93·4 lb. per acre.

TABLE No 3.

Exhaustibility of Crops Experiment.

Testing Crop—Cotton—Variety—Allen.

No. of Plot.	Treatment.	Yields of 1925 crops in lb. per acre.	Yields of seed cotton in lb. per acre.	Increase (+) or (−) decrease as compared with mean of adjacent controls in lb. per acre.
Block A				
Plot 14	Groundnuts	368	348	
„ 15	Maize	171	376	− 16
.. 16	Groundnuts	288	436	
.. 17	Guinea corn ...	543	452	+ 12
.. 18	Groundnuts	384	444	
.. 19	Cotton	364	364	− 22
.. 20	Groundnuts	340	328	
.. 21	Maize	171	260	− 34
.. 22	Groundnuts	248	260	
.. 23	Guinea corn ...	195	192	+ 18
.. 24	Groundnuts	136	88	
„ 25	Cotton	156	104	− 8
„ 26	Groundnuts	240	136	

Each plot ¼ acre. Single stands 15" apart on ridges 4' apart.

Sown July 3rd, 1926.

Picked.—December 17th, 1926.
January 1st, 1927.
January 17th, 1927.
February 2nd, 1927.

Increase (+) or decrease (−) of plots sown with Maize as compared with plots sown with Groundnuts.	Increase (+) or decrease (−) of plots sown with Guinea corn as compared with plots sown with Groundnuts.	Increase (+) or decrease (−) of plots sown with Cotton as compared with plots sown with Groundnuts.
− 16 lb. per acre.	+ 12 lb. per acre.	− 22 lb. per acre.
− 34 „ „ „	+ 18 „ „ „	− 8 „ „ „
Average − 25 ± 69 lb. per acre.	+ 15 ± 69 lb. per acre.	− 15 ± 69 lb. per acre.

Root—mean—square—difference between neighbouring control plots = 98 lb. per acre.

Cost of cultivation in man-days per acre = 91·3.

TABLE No. 3A.

Exhaustibility of Crops Experiment—Cash Returns.

Block A, Plots 14–26.

Exhausting Crop, 1925.	Yield and condition per acre.	Price.	Cash Return per acre.	Testing Crop, 1926.	Yield and condition per acre.	Price.	Cash Return per acre.	Total Cash return per acre.
			£ s. d.				£ s. d.	£ s. d.
Guinea Corn	372 lb. dry threshed grain.	1d. per lb.	2 6 8	Cotton	328 lb. seed cotton	1⅛d. per lb.	2 5 4	4 12 0
Cotton	260 lb. seed cotton	1⅛d. per lb.	2 11 4	..	236	1⅛d. per lb.	1 11 8	4 3 0
Groundnuts	288 lb. dry unshelled nuts.	$\frac{9}{10}$d. per lb.	1 1 8	..	292	1⅛d. per lb.	1 19 8	3 1 4
Maize	172 lb. threshed grain	¾d. per lb.	10 8	..	320	1⅛d. per lb.	2 3 0	2 13 8

TABLE No. 4A.

Exhaustibility of Crops Experiment—Cash Returns.

Block A, Plots 27–39.

Groundnuts	252 lb. dry unshelled nuts.	$\frac{9}{10}$d. per lb.	0 19 0	Guinea Corn.	784 lb. dry threshed grain.	1d. per lb.	3 5 4	4 4 4
Cotton	156 lb. seed cotton	1⅛d. per lb.	1 1 4	..	588 lb. dry threshed grain.	1d. ..	2 8 8	3 10 0
Maize	172 lb. threshed grain	¾d. per lb.	10 8	..	700 lb. dry threshed grain.	1d. ..	2 18 4	3 9 0
Guinea Corn	204 lb. dry threshed grain.	1d. per lb.	17 0	..	548 lb. dry threshed grain	1d. ..	2 5 8	3 2 8

TABLE No. 4.

EXHAUSTIBILITY OF CROPS EXPERIMENT.

Testing Crop—Guinea Corn—Yellow—Seeded Variety.

No. of Plots.	Treatment.	Yield of 1925 Crops in lb. per acre.	Yield of G. Corn heads in lb. per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls, in lb. per acre.
Block A				
Plot 27	Groundnuts ...	236	1,492	
,, 28	Maize	171	950	− 341
,, 29	Groundnuts ...	372	1,090	
,, 30	Guinea corn ...	237	646	− 416
,, 31	Groundnuts ...	360	1,034	
,, 32	Cotton ...	152	754	− 197
,, 33	Groundnuts ...	252	868	
,, 34	Maize	171	912	− 215
,, 35	Groundnuts ...	240	1,386	
,, 36	Guinea corn ...	168	818	− 187
,, 37	Groundnuts ...	164	624	
,, 38	Cotton ...	160	814	+ 96
,, 39	Groundnuts ...	140	812	

Each plot ¼ acre. Guinea Corn spaced 3′ apart on ridges 4′ apart.
Sown May 11th, 1926. Harvested November 30th, 1926.

Increase (+) or decrease (−) of plots sown with Maize as compared with plots sown with Groundnuts.	Increase (+) or decrease (−) of plots sown with G. Corn as compared with plots sown with Groundnuts.	Increase (+) or decrease (−) of plots sown with Cotton as compared with plots sown with Groundnuts.
− 341 lb. per acre.	− 416 lb. per acre.	− 197 lb. per acre.
− 215 ,, ,, ,,	− 187 ,, ,, ,,	+ 96 ,, ,, ,,
Average −278 ∓300 lb. p.a.	Average − 301 ∓300 lb. p.a.	Average − 50 ∓300 lb. p.a.

Root—mean—square—difference between neighbouring controls plots = 423·6 lb. per acre.
Cost of cultivation in man-days per acre = 61·5.

TABLE No. 5.

GROUNDNUTS—VARIETY TEST.

No. of Plots.	Variety.	Yield of dry unshelled nuts in lb. per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
Block D.			
Plot 1	Non-Experimental	...	...
„ 2	Zaria	876	
„ 3	American ...	900	+ 52
„ 4	Zaria	820	
„ 5	Chinese	696	− 58
„ 6	Zaria	688	
„ 7	Gambia	612	− 4
„ 8	Zaria	548	
„ 9	Kano	664	+ 50
„ 10	Zaria	680	
„ 11	Ilorin 2	812	+ 182
„ 12	Zaria	580	
„ 13	American	376	− 176
„ 14	Zaria	524	
„ 15	Chinese	652	+ 76
„ 16	Zaria	628	
„ 17	Gambia	688	− 14
„ 18	Zaria	776	
„ 19	Kano	728	+ 4
„ 20	Zaria	672	
„ 21	Ilorin 2	572	− 86
„ 22	Zaria	644	
„ 23	American	616	− 50
„ 24	Zaria	688	
„ 25	Chinese	752	+ 144
„ 26	Zaria	528	
„ 27	Gambia	484	− 18
„ 28	Zaria	476	
„ 29	Kano	448	− 112
„ 30	Zaria	644	
„ 31	Ilorin 2	664	+ 54
„ 32	Zaria	576	
„ 33	Non-Experimental ...	...	

Each plot ¼ acre. Ridges 4' apart. Stands 30" apart on both sides of ridge.
Sown June 12th, 1926. Harvested November 16-27, 1926.

Increase (+) or decrease (−) of plots of American as compared with plots of Zaria.
+ 52 lb. per acre.
− 176 „ „ „
− 50 „ „ „
Average − 58 ± 63 lb. per acre.

Increase (+) or decrease (−) of plots of Chinese as compared with plots of Zaria.
− 58 lb. per acre.
+ 76 „ „ „
+144 „ „ „
Average + 54 ± 63 lb. per acre.

Increase (+) or decrease (−) of plots of Gambia as compared with plots of Zaria.
− 4 lb. per acre.
− 14 „ „ „
− 18 „ „ „
Average − 12 ± 63 lb. per acre.

Increase (+) or decrease (−) of plots of Ilorin 2 as compared with plots of Zaria.
+ 182 lb. per acre.
− 86 „ „ „
+ 54 „ „ „
Average +50 ± 63 lb. per acre.

Increase (+) or decrease (−) of plots of Kano as compared with plots of Zaria.
+ 50 lb. per acre.
+ 4 „ „ „
− 112 „ „ „
Average − 19 ± 63 lb. per acre.

Root—mean—square—Difference between neighbouring controls =109 lb. per acre.
Cost of cultivation in man-days per acre =138.

TABLE 6A.

SHELLING PERCENTAGES.

Variety.	American.	Chinese.	Gambia.	Ilorin 2.	Kano.	Zaria.
Percentage shelled nuts to unshelled	72·8	72·8	71·8	69·0	71·0	72·0

Note. The usual spacing is 15 inches apart on both sides of the ridge.

TABLE No. 6.

Interplanted Cowpeas—Date of Planting Test

Variety—Local.

No. of Plots.	Date of Planting.	Yield of seed cotton in lb. per acre.	Yield of dry threshed peas in lb. per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
Block D.				
Plot 34	August 1st ...	64	19	
,, 35	July 15th ...	80	28	+ ·5
,, 36	August 1st ...	84	36	
,, 37	August 15th ...	168	14	− 11
,, 38	August 1st ...	88	14	
,, 39	July 15th ...	92	26	+ 12
,, 40	August 1st ...	176	14	
,, 41	August 15th ...	144	5	− 16·5
,, 42	August 1st ...	128	29	
,, 43	July 15th ...	84	31	+ 3·5
,, 44	August 1st ...	172	26	
,, 45	August 15th ...	216	18	− 9·5
,, 46	August 1st ...	148	29	
,, 47	July 15th ...	176	38	+ 11·5
,, 48	August 1st ...	200	24	
,, 49	August 15th ...	204	19	− 3
,, 50	August 1st ...	124	20	
,, 51	July 15th ...	76	7	− 9·5
,, 52	August 1st ...	64	13	
,, 53	August 15th ...	116	5	− 14
,, 54	August 1st ...	152	25	
,, 55	July 15th ...	152	49	+ 28·5
,, 56	August 1st ...	96	16	
,, 57	August 15th ...	132	17	− 20
,, 58	August 1st ...	168	58	
,, 59	July 15th ...	148	30	− 16·5
,, 60	August 1st ...	148	35	
,, 61	August 15th ...	124	17	− 16
,, 62	August 1st ...	92	31	
,, 63	July 15th ...	112	14	− 12·5
,, 64	August 1st ...	92	22	
,, 65	August 15th ...	88	7	− 15
,, 66	August 1st ...	116	22	

Plots ¼ acre. Ridges 4′ apart. Cotton planted 15″ apart, cowpeas interplanted every fifth space=5′ 5″ apart.

Cotton.—Sown June 30, 1926. *Picked.*—December 12, 1926.
January 8, 1927.
January 19, 1927.

Cowpeas planted on above dates. *Harvested*—December 18, 1926.

Increase (+) or decrease (−) of plots sown on July 15th, compared with plots sown August 1st.

+ ·5 lb. per acre.
+12·0 ,, ,,
+ 3·5 ,, ,,
+11·5 ,, ,,
− 9·5 ,, ,,
+28·5 ,, ,,
−16·5 ,, ,,
−12·5 ,, ,,

Average + 2·2 ± 5·4 lb. per acre.

Increase (+) or decrease (−) of plots sown on August 15th, compared with plots sown August 1st.

− 11 lb. per acre.
− 16·5 ,, ,,
− 9·5 ,, ,,
− 3·0 ,, ,,
− 14·0 ,, ,,
− 20·0 ,, ,,
− 16·0 ,, ,,
− 15·0 ,, ,,

Average − 13·1 ± 5·4 lb per acre.

Root—mean—square—difference between neighbouring control plots 15·3 lb. per acre
Cost of cultivation of cowpeas in man-days per acre = 8.
Cost of cultivation of cotton in man-days per acre = 75·2.

TABLE No. 7.

Farmyard Manure *versus* Kraaling Experiment.

No. of Plots.	Treatment.	Yield of Seed cotton in lb. per acre.		Increase (+) or decrease (−) compared with mean of adjacent controls.
Block E.	*Crop:*—Cotton-variety, Allen			
Plot 34	400 Cattle-nights Kraaled ...	136		
,, 35	100 Cattle-nights stall-fed		172	− 12
,, 36	400 Cattle-nights Kraaled ...	232		
,, 37	200 Cattle-nights stall-fed		252	+ 16
,, 38	400 Cattle-nights Kraaled ...	240		
,, 39	300 Cattle-nights stall-fed		216	− 28
,, 40	400 Cattle-nights Kraaled ...	248		
,, 41	400 Cattle-nights stall-fed		264	− 34
,, 42	400 Cattle-nights Kraaled ...	348		
,, 43	100 Cattle-nights stall-fed		300	− 4
,, 44	400 Cattle-nights Kraaled ...	260		
,, 45	200 Cattle-nights stall-fed		332	+ 36
,, 46	400 Cattle-nights Kraaled ...	332		
,, 47	300 Cattle-nights stall-fed		344	+ 44
,, 48	400 Cattle-nights Kraaled ...	268		
,, 49	400 Cattle-nights stall-fed		344	+ 90
,, 50	400 Cattle-nights Kraaled ...	240		
,, 51	100 Cattle-nights stall-fed		220	− 48
,, 52	400 Cattle-nights Kraaled ...	296		
,, 53	200 Cattle-nights stall-fed		292	− 8
,, 54	400 Cattle-nights Kraaled ...	304		
,, 55	300 Cattle-nights stall-fed		412	+138
,, 56	400 Cattle-nights Kraaled ...	244		
,, 57	400 Cattle-nights stall-fed		372	+130
,, 58	400 Cattle-nights Kraaled ...	240		
,, 59	100 Cattle-nights stall-fed		296	+ 34
,, 60	400 Cattle-nights Kraaled ...	284		
,, 61	200 Cattle-nights stall-fed		300	+ 10
,, 62	400 Cattle-nights Kraaled ...	296		
,, 63	300 Cattle-nights stall-fed		268	− 14
,, 64	400 Cattle-nights Kraaled ...	268		
,, 65	400 Cattle-nights stall-fed		392	+134
,, 66	400 Cattle-nights Kraaled ...	248		

Each plot ¼ acre. Cotton planted July 12th, 1926 and picked December 10th, 1926.
,, 27th, ,,
January 19th, 1927.

Ridges 4′ apart. Spacings 15″ with one plant to a stand.

The manure was applied as follows :—

Controls.—Cattle were pastured in the bush during the day and were tethered on the farm at night at the rate of 400 cattle per acre.

Treatments.—Manure was made in an open yard, cattle receiving 8 lb. bedding per head per day and prior to planting the manure in the yard was weighed and the amounts equivalent to 400, 300, 200 and 100 stall-fed cattle-nights calculated and applied at the rates of

400 stall-fed cattle-nights = 6 tons manure per acre.
300 ,, ,, = 4½ ,, ,, ,,
200 ,, ,, = 3 ,, ,, ,,
100 ,, ,, = 1½ ,, ,, ,,

TABLE No. 7—*contd.*

Increase (+) or decrease (−) of crop on plots receiving 100 stall-fed cattle-nights as compared with crop on plots with 400 cattle-nights Kraaled.		Increase (+) or decrease (−) of crop on plots receiving 200 stall-fed cattle-nights as compared with crop on plots receiving 400 cattle-nights Kraaled.	
− 12 lb. per acre.		+ 16 lb. per acre.	
− 4 „ „		+ 36 „ „	
− 48 „ „		− 8 „ „	
+ 34 „ „	Average − 7·5 ± 27 lb. per acre.	+ 10 „ „	Average + 13·5 ± 27 lb. per acre.
Increase (+) or decrease (−) of crop on plots receiving 300 stall-fed cattle-nights as compared with crop on plots receiving 400 cattle-nights Kraaled.		Increase (+) or decrease (−) of crop on plots receiving 400 stall-fed cattle-nights as compared with crop on plots receiving 400 cattle-nights Kraaled.	
− 28 lb. per acre.		− 34 lb. per acre	
+ 44 „ „		+ 90 „ „	
+138 „ „		+130 „ „	
− 14 „ „	Average + 35 ± 27 lb. per acre.	+134 „ „	Average + 80 ± 27 lb. per acre.

Root—mean—square—difference between neighbouring controls = 54·3 lb. per acre.

Cost of cultivation in man-days per acre = 85.

Additional cost Control Plots :—

Herding cattle and spreading manure in man-days per acre = 4

Total = 89.

Additional cost Treatment Plots :—

Weighing Fym. in man-days per acre = 10·5*

Loading „ „ „ = 4·0

Carting „ „ „ = 3·0

Spreading „ „ „ = 3·5

Total = 106.0.

* This is not a true charge but only due to Experimental Conditions.

TABLE No. 8.

Manurial Experiment.

Nigerian Rock Phosphate and Farm Yard Manure.

No. of plot.	Treatment.	Yield of dry unshelled nuts in lb. per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
Block Y.	Crop:—Groundnuts		
Plot 1	Unmanured	351	
2	FYM+Phosphate	572	+ 234
3	Unmanured	325	
4	Phosphate	559	+ 182
5	Unmanured	429	
6	FYM.	507	+ 117
7	Unmanured	351	
8	FYM+Phosphate	715	+ 345
9	Unmanured	390	
10	Phosphate	676	+ 293
11	Unmanured	377	
12	FYM.	351	+ 72
13	Unmanured	182	

Each Plot 1/13th acre. Ridges 4′ apart. Spacing 15″ apart on both sides of ridge.

Planted—June 23rd, 1926. Harvested—November 11th–13th, 1926.

Nitrogen applied in form of cattle manure at the rate of 2,000lbs. per acre (equivalent to 26lbs. N_2 per acre.)

Phosphate applied in form of crudely crushed Nigerian Rock Phosphate at the rate of ½ ton per acre (equivalent to 300lbs. P_2O_5 per acre).

In the combined manuring of plots 2 and 8 the same rates were adhered to.

Increase (+) or Decrease (−) of crop on plots treated with FYM+Phosphates as compared with unmanured plots.	Increase (+) or Decrease (−) of crop on plots treated with phosphates alone as compared with unmanured plots.	Increase (+) or Decrease (−) of crops on plots treated with FYM alone as compared with unmanured plots.
+234 lb. per acre.	+182 lb. per acre.	+117 lb per acre.
+345 „ „ „	+293 „ „ „	+ 72 „ „ „
Average + 289 ± 69 lb. per acre.	Average + 237 ± 69 lb. per acre.	Average + 94 ± 69 lb. per acre.

Root—mean—square—difference between neighbouring controls plots = 97·7 lb. per acre.

Cost of cultivation in man-days per acre = 156.

Cost of application of manures in man-day per acre = 8.

TABLE No. 8.—*continued*

MANURIAL EXPERIMENT—NIGERIAN ROCK PHOSPHATE AND FARM YARD MANURE.

No of plots.	Treatment.	Yield of dry unshelled nuts in lb. per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
Block Z.	Crop:—Groundnuts.		
Plot 1	Unmanured	598	
2	FYM+Phosphate ...	897	+ 351
3	Unmanured	494	
4	Phosphate	67	+ 208
5	Unmanured	442	
6	FYM	689	+ 351
7	Unmanured	234	
8	FYM+Phosphate ...	780	+ 520
9	Unmanured	286	
10	Phosphate	572	+ 377
11	Unmanured	104	
12	FYM	377	+ 299
13	Unmanured	52	

All data exactly the same as in Block Y.

Increase (+) or decrease (−) of plots manured with FYM+ Phosphate over unmanured plots.	Increase (+) or decrease (−) of plots manured with Phosphate alone over unmanured plots.	Increase (+) or decrease (−) of plots manured with FYM alone over unmanured plots.
+351 lb. per acre.	+208 lb. per acre.	+351 lb. per acre.
+520 „ „ „ .	+377 „ „ „	+299 „ „ „
Average +435±89 lb. p.a.	Average +292±89 lb. p.a.	Average +325±89 lb. p.a.

Root—mean—square—difference between neighbouring controls. 126 lbs. per acre.

Cost of cultivation in man days per acre = 156.

Cost of application of manures in man-days per acre = 8

NOTE:—The groundnuts in plots 11 and 13 germinated very badly owing to water logging and resowing was necessary over the whole plot.

TABLE No. 9.

Costs of Cultivation of Main Crops Season, 1926–27 in Man-days per acre.

Crop.	Preparation.	Sowing and Establishing.	After cultivation.	Harvesting.	Sundry operation.	Total Man days per acre.
Cotton alone ...	39·25	2·8	21·3	20·5	·8	84·65
Cotton and Cow-pea	23·2 —	2·4 4·0	29·6 —	16·0 4·0	— —	71·2 8·0
Early green manure followed by Cotton ...	— 32·3	10·0+8·0 3·2	— 26·2	— 34·2	— 4·2	18·0 100·1
Guinea Corn alone	15·7	3·5+0·1	29·4	12·9	—	61·6
Groundnuts ...	25·5	7·8+3·2	10·9	79·6	11·3	138·3
Mucuna fodder crop (hay) ...	29·6	4·5+ ·7	7·7	13·1	8·4	64·0

Note:—Pay of labourers = 9d. per diem.

TABLE No. 10.

Comparison of Cost of Production and Revenue from Main Crops, 1926–27.

Crop.	Cost in Man-days	Average yield per acre in lb.	Cost of crop in Man-days per lb.	Assumed Market value per lb. in the same condition.	Calculation Return per acre including transport to market.	Monetary Return per Man-day in pence.	Condition of Crop.
					£ s. d.		
Groundnuts (Zaria) ...	138·3	720	·192	·926d.	2 13 7	3·9d.	Undecorticated.
Guinea Corn (alone) (Kaura)	61·6	1,044	·059	·700d.	3 0 11	11·9d.	Unthreshed.
Gero (8 rows with Mucuna) (Wuyan Bijimi)	17·0	571	·030	·333d.	0 15 10	11·2d.	Unthreshed.
Cotton (following early Green Manure) (Allen)	100·1	426	·426	1·625d.	2 16 6	6·8d.	Seed Cotton.
Cotton (alone) (Allen) ...	70·3	152	·462	1·625d.	1 0 2	3·4d.	Seed Cotton.
Cowpeas (Local) ...	18·0	25	·72	·72d.	0 1 7	1·1d.	Threshed.

Note.—Cowpeas were a failure owing to the early cessation of the rains.

ANNUAL REPORT, KANO AGRICULTURAL STATION, 1926.

General.—The station is situated about three miles south of Kano city and half a mile from the village of Nassarawa, or approximately 8° 30 west and 12° north at an altitude of 1,500 feet, the nearest point to the coast being 500 miles. The total area is 160 acres of which 146¼ acres are cultivated. The farm is divided for experimental purposes into quarter acre plots. The surrounding land is all taken up with native farms, but, being in the highly populated area of Kano, corn crops for local consumption are grown principally. These farms are worked in a number of cases by inhabitants of Kano city who only come out to their farms during the farming season, *i.e.*, April-November. The land is naturally poor and large dressings of manure are applied.

Attached to the station are fifteen oxen, three cows and a calf which were purchased in order to test the economic possibilities of mixed farming.

2. *Cropping Notes.*—The low yields obtained in 1925 resulted from the poor condition of the farm; for very little manure had been applied during the previous two seasons. In the year under review, as much of the farm as possible received a dressing of approximately one ton of manure per acre excepting the areas which were under special manurial experiments.

Even one ton per acre does not compare favourably with the three tons per acre which is the amount approximately used each year on farms near Kano. However, this small dressing had a certain very beneficial effect, in so far that, the crops were more level and compared very favourably with those of the surrounding farms, cotton and groundnuts being conspicuously better.

The season 1926 has been somewhat abnormal; for the rains broke early but were not evenly distributed over the wet season and finished early. In consequence crops which, at the beginning of the season, appeared thriving lacked moisture towards the end of their growing period and yields suffered accordingly.

Ploughing and cultivation by bullock-drawn implements has been begun. The work done has been encouraging, though still in an experimental stage.

A plough is being devised which can be made practically outright by the natives in their own villages from local materials. When this is possible one of the greatest drawbacks to animal cultivation, *i.e.*, cost, will be overcome.

The tendency of experiments then, is to obtain a workable method of mixed farming using cattle as draft and dairy animals and as manufacturers of farm yard manure. Arising out of this there has been a question of fodder and the best method of demonstrating to the native that if he keeps cattle for work they will have to be specially provided for in his scheme of farming. Experiments have shown mucuna to be the best and bulkiest fodder for all practical purposes. It makes good hay and if cut during the period of maximum growth gives a very excellent yield. Two other legumes were grown for fodder, cowpeas (Hausa *wake*) and dolichos. The former will always be sown, most probably as an interplanted crop as at present, with the seed used for human consumption and the haulm as hay; but grown as a single crop it has not been a success, owing to its not being a good drought resister and consequently only giving a poor yield. Dolichos was experimented with first as a green manurial crop but the short growing season of the north was unfavourable and made it impossible to obtain a good cover; also it is not a good drought resister and is of no value for human food. It has been discarded.

The outstanding features of the season under review have been:

(*a*) The great advantages obtained from manure on this soil even when only a very light dressing has been applied.

(*b*) The failure of crops tried other than mucuna to make hay of any quality, *i.e.*, cowpeas, dolichos and canavalia.

(*c*) The necessity for fodder crops in mixed farming in this Province when natural fodder is scarce.

(*d*) Ploughing and cultivating with the aid of bullocks.

(*e*) The failure of green manuring, due to the short growing period available, lack of sufficient rains to establish the crop as a catch crop, and lack of manual labour to deal with it during the season when the care of the food crops, etc., are of the utmost importance.

J. W. R. PEDDER.

Kano,
31st March, 1927.

Cotton Allen One Rate of Manuring Experiment.

(*See* Table No. 1.)

	Seed Cotton lb. per acre.	Odds that difference is significant.
Average yield 31 control plots	389	—
Average difference 7 plots with 3 tons per acre	-55 ± 40	11 : 1
Average difference 7 plots with 7 tons per acre	$+48 \pm 40$	8 : 1
Average difference 7 plots with 9 tons per acre	-14 ± 40	—
Average difference 7 plots with 11 tons per acre	-14 ± 40	—

The yields of cotton on this block were fairly good and the crop with the exception of plots 16-25 was level throughout its growing period. The manure was broadcast over the plots before ridging and planting. The manure used was bought from the Kano town and varied very greatly in quality. Owing to the lack of rains it probably did not decompose sufficiently to be of maximum use to the plants.

This experiment is being repeated when it is hoped more conclusive results will be obtained. But indications tend to show that an increased yield will be obtained by applying manure up to at least five tons per acre.

Cotton Strains Test.

(*See* Table No. 2.)

	Seed Cotton lb. per acre.	Odds that difference is significant.
Average yield 9 control plots Allen 1 ...	308	—
Average difference 4 plots Allen 5 as compared with Allen 1	$-22 \pm 40{\cdot}8$	2 : 1
Average difference 4 plots Allen 13 as compared with Allen 1	$-41 \pm 40{\cdot}8$	6 : 1

The growth was very good in this block with the exception of the first three plots, the first two of which are affected by a large excavation and by a well. However, the first plot is non-experimental.

Groundnuts, Phosphate Experiment.

(*See* Table No. 3 (*a*)).

	Groundnuts dry undecorticated lb. per acre.	Odds that difference is significant.
Average yield 13 control plots	513	—
Average difference 4 plots with N_2 as dung	$+ 29 \pm 60$	2 : 1
Average difference 4 plots with P_2O_5 as hand-ground rock phosphate	$+ 55 \pm 60$	5 : 1
Average difference 4 plots with P_2O_5 & N_2	$+155 \pm 60$	160 : 1

The groundnuts were not planted as early as others on the farm and to some extent suffered from drought and in consequence the yield is not very high. Another difficulty with this block is that it appears more overrun with termites (white ants) than any other on the Plantation; they did considerable damage to the nuts during the ripening period. The results are interesting in so far that no very appreciable result is obtained from either nitrogen or phosphate alone but in combination the manures appear to cause a considerable increase. This experiment is run in conjunction with that of mucuna, Table No. 3 (*b*) below.

Mucuna Phosphate Experiment.

(*See* Table No. 3 (*b*)).

	Wt. of mucuna as dry hay lb. per acre.	Odds that difference is significant.
Average yield of dry mucuna of 13 control plots	1,174	—
Average difference 4 plots with N_2	$+435 \pm 155$	390 : 1
Average difference 4 plots with P_2O_5	$+437 \pm 155$	390 : 1
Average difference 4 plots with N_2 & P_2O_5 ...	$+332 \pm 155$	55 : 1

This experiment demonstrates clearly the increase in yield of mucuna when a manurial dressing is given. Comparing this and the parallel experiment (Table No. 4 (*a*)), it is seen that with groundnuts a combination of manures appears desirable whereas with mucuna the manures singly have a distinctly beneficial effect.

Groundnut Variety Test.

(*See* Table No. 4.)

	Wt. of dry undecorticated groundnuts lb. per acre.	Odds that difference is significant.
Average yield 24 control plots Kano Variety	1,881	—
Average difference 5 plots Ilorin Variety ...	-239 ± 109	55 : 1
Average difference 5 plots Zaria Variety ...	$+ 11 \pm 109$	—
Average difference 5 plots American Y Variety	$- 99 \pm 109$	5 : 1
Average difference 4 plots Chinese Variety	-199 ± 121	17 : 1
Average difference 4 plots Gambia Variety	-184 ± 121	14 : 1

This was one of the most satisfactory experiments this year. The crop at all times looked very well and was conspicuously better than those on the surrounding farms. The experiment was identical with that of last year and again demonstrates the superiority of Kano variety of groundnuts in point of yield.

	Per cent.
Kano	68
Ilorin	61
Zaria	67
American "Y"	66
Chinese	66
Gambia	64

These percentages were obtained by the ordinary method of native decortication, *i.e.*, mortar and pestle, and no special care was taken to get a high percentage.

Date of Planting Maiwa and Mucuna.

(*See* Table No. 5.)

	Mucuna as dry hay in lb. per acre.	Odds that difference is significant.
Average yield of 9 plots Mucuna planted 10th July	1,046	—
Average difference of 4 plots planted 26th June with standard	+281±154	27 : 1
Average difference of 4 plots planted 24th July with standard	— 95±154	3 : 1

The maiwa in this experiment was a complete failure and did not head and in consequence mucuna only was cut and taken into account. It is interesting to note that there appears to be a distinct advantage in yield by planting mucuna early when required for hay and it would appear that mid-June gives the maximum yield. The mucuna when cut was just showing signs of drying off through drought in all plots of the experiment.

The Cost of Main Crop in Man Days Per Acre.

(*See* Table No. 6.)

The costs in man days per acre appears low in comparison with work done previously but this is due to two causes:

(*a*) The poor yields obtained and in some cases failures which necessitated very little work.

(*b*) The utilisation during part of the season of animal cultivation.

Comparison of Cost of Production and Revenue from Main Crops 1926-27 Season.

(*See* Table No. 7.)

Revenue appears high due to higher prices this season, small crops, and lower cost of production.

Rainfall and Temperature.

(*See* Table No. 8.)

Monthly rainfall and temperature during the season under review and average for the previous six years.

J. W. R. PEDDER,
Superintendent of Agriculture.

Nassarawa, Kano,
7th April, 1927.

TABLE No. 1.

Rate of Manuring Experiment.

No. of Plot.	Treatment.	Yields of cotton lb. per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
Block K.			
1	At the rate of 5 tons per acre.	442	
2	" " 3 " "	397	− 73
3	" " 5 " "	499	
4	" " 11 " "	512	− 14
5	" " 5 " "	553	
6	" " 7 " "	559	+ 40
7	" " 5 " "	485	
8	" " 9 " "	472	+ 22
9	" " 5 " "	415	
10	" " 3 " "	361	− 39
11	" " 5 " "	385	
12	" " 11 " "	494	+ 16
13	" " 5 " "	471	
14	" " 7 " "	495	+ 4
15	" " 5 " "	430	
16	" " 9 " "	320	− 3
17	" " 5 " "	280	
18	" " 3 " "	288	+ 1
19	" " 5 " "	266	
20	" " 11 " "	235	−
21	" " 5 " "	209	
22	" " 7 " "	284	+
23	" " 5 " "	241	
24	" " 9 " "	273	+
25	" " 5 " "	234	
26	" " 3 " "	229	−
27	" " 5 " "	562	
28	" " 11 " "	260	−
29	" " 5 " "	316	
30	" " 7 " "	358	+
31	" " 5 " "	246	
32	" " 9 " "	311	+
33	" " 5 " "	361	
34	" " 3 " "	393	+
35	" " 5 " "	422	
36	" " 11 " "	469	+
37	" " 5 " "	502	
38	" " 7 " "	502	−
39	" " 5 " "	531	
40	" " 9 " "	423	−
41	" " 5 " "	350	
42	" " 5 " "	326	N
43	" " 5 " "	436	
44	" " 3 " "	419	-

TABLE No. 1—*continued.*

No. of Plot.	Treatment.	Yields of cotton lb. per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
45	At the rate of 5 tons per acre.	457	
46	„ „ 11 „ „	483	+ 25
47	„ „ 5 „ „	459	
48	„ „ 7 „ „	645	+ 191
49	„ „ 5 „ „	450	
50	„ „ 9 „ „	446	− 88
51	„ „ 5 „ „	619	
52	„ „ 3 „ „	487	− 95
53	„ „ 5 „ „	546	
54	„ „ 11 „ „	464	− 23
55	„ „ 5 „ „	429	
56	„ „ 7 „ „	314	− 62
57	„ „ 5 „ „	324	
58	„ „ 9 „ „	248	− 28
59	„ „ 5 „ „	228	

Each Plot ¼ acre. Ridges 3′ 6″. Sown July 23rd, 1926. Harvested Nov., 1926 to Jan., 1927.

Increase (+) or decrease (−) of 7 plots of 3 tons per acre compared with 5 tons per acre.

− 73 lb. per acre.
− 39 „ „ „
− 15 „ „ „
− 169 „ „ „
+ 2 „ „ „
− 27 „ „ „
− 95 „ „ „

Average − 55 ± 40 lb. per acre.

Increase (+) or decrease (−) of 7 plots of 7 tons per acre compared with 5 tons per acre.

+ 40 lb. per acre.
+ 45 „ „ „
+ 59 „ „ „
+ 77 „ „ „
− 14 „ „ „
+ 191 „ „ „
− 62 „ „ „

Average + 48 ± 40 lb. per acre.

Increase (+) or decrease (−) of 7 plots of 9 tons per acre compared with 5 tons per acre.

+ 22 lb. per acre.
− 35 „ „ „
+ 36 „ „ „
+ 8 „ „ „
− 17 „ „ „
− 88 „ „ „
− 28 „ „ „

Average − 14 ± 40 lb. per acre.

Increase (+) or decrease (−) of 7 plots of 11 tons per acre compared with 5 tons per acre.

− 14 lb. per acre.
+ 66 „ „ „
− 2 „ „ „
− 179 „ „ „
+ 7 „ „ „
+ 25 „ „ „
− 23 „ „ „

Average − 14 ± 40 lb. per acre.

Root—mean—square—difference between pairs of neighbouring controls = 106·42.

Cost of cultivation in Man-days per acre = 59·6.

TABLE No. 2.

Cotton Strains Test.

No. of Plot.	Variety.	Yield of seed cotton lb. per acre.	Increase (+) or decrease (−) compared with mean of adjacent control.
Block G.			
1	Allen No. 1	78	Non experimental
2	,, ,, 1	88	
3	,, ,, 5	138	− 8
4	,, ,, 1	205	
5	,, ,, 13	236	− 15
6	,, ,, 1	298	
7	,, ,, 5	272	− 13
8	,, ,, 1	272	
9	,, ,, 13	306	+ 1
10	,, ,, 1	339	
11	,, ,, 5	308	− 35
12	,, ,, 1	361	
13	,, ,, 13	315	− 46
14	,, ,, 1	361	
15	,, ,, 5	397	− 32
16	,, ,, 1	497	
17	,, ,, 13	320	−103
18	,, ,, 1	350	

Each plot ¼ acre. Ridges 3′ 6″. Sown 24th June, 1926. Harvested 8th November, 1926.

Increase (+) or derease (−) of 4 plots of variety Allen 5 as compared with variety Allen 1.

− 8 lb. per acre
− 13 ,, ,, ,,
− 35 ,, ,, ,,
− 32 ,, ,, ,,

Average − 22 ± 40·8 lb. per acre

Increase (+) or decrease (−) of 4 plots of variety Allen 13 as compared with variety Allen 1.

− 15 lb. per acre
+ 1 ,, ,, ,,
− 46 ,, ,, ,,
−103 ,, ,, ,,

Average − 41 ± 40·8 lb. per acre.

Root—mean—square—difference between pairs of neighbouring control plots = 81·6.

Cost of cultivation in Man-days per acre = 59·6.

TABLE No. 3a.

Groundnuts Phosphate Experiment.

No. of Plot.	Treatment.	Yields of Groundnuts in lb. per acre dry undecorticated.	Increase (+) or decrease (−) compared with mean of adjacent controls.
Block E. 1–25			
1	No manure	605	
2	Dung	815	+ 183
3	No manure	660	
4	P_2O_5	825	+ 85
5	No manure	820	
6	P_2O_5 and dung ...	960	+ 233
7	No manure	635	
8	Dung	570	± 0
9	No manure	505	
10	P_2O_5	828	+ 276
11	No manure	600	
12	P_2O_5 and dung ...	560	+ 43
13	No manure	435	
14	Dung	425	− 32
15	No manure	480	
16	P_2O_5	260	− 167
17	No manure	375	
18	P_2O_5 and dung ...	640	+ 215
19	No manure	475	
20	Dung	355	− 35
21	No manure	305	
22	P_2O_5	375	+ 28
23	No manure	390	
24	P_2O_5 and dung ...	520	+ 130
25	No manure	390	

Each plot $\frac{1}{10}$ acre. Ridges 3′ 6″. Sown July 5th, 1926. Harvested 29th November, 1926.

Increase (+) or decrease (−) of 4 plots with dung added compared with no Manure.	Increase (+) or decrease (−) of 4 plots with P_2O_5 added compared with no Manure.	Increase (+) or decrease (−) of 4 plots with P_2O_5 and dung. added compared with no Manure.
+ 185 lb. per acre.	+ 85 lb. per acre.	+ 233 lb. per acre.
± 0 ,, ,,	+ 276 ,, ,,	+ 43 ,, ,,
− 32 ,, ,,	− 167 ,, ,,	+ 215 ,, ,,
− 35 ,, ,,	+ 28 ,, ,,	+ 130 ,, ,,
Average + 29±60 per acre.	Average + 55±60 per acre.	Average + 155±60 per acre.

Root — mean— square — difference between pairs of neighbouring control plots — 121.

Cost of cultivation in Man Days per acre = 52·2.

TABLE No. 3b.

MUCUNA PHOSPHATE EXPERIMENT.

No. of Plot.	Treatment.	Yields of Mucuna as dry hay in lb. per acre.	Increase (+) or Decrease (−) as com pared with mean of adjacent controls.
Block E.			
1	No manure	1,160	Non-experimental.
2	Dung	1,440	+ 360
3	No manure	1,000	
4	P_2O_5	1,880	+ 820
5	No manure	1,120	
6	P_2O_5 and dung ...	1,760	+ 620
7	No manure	1,160	
8	Dung	1,920	+ 720
9	No manure	1,240	
10	P_2O_5	1,560	+ 400
11	No manure	1,080	
12	P_2O_5 and dung ...	1,680	+ 400
13	No manure	1,480	
14	Dung	1,880	+ 240
15	No manure	1,800	
16	P_2O_5	1,400	− 40
17	No manure	1,080	
18	P_2O_5 and dung ...	1,400	+ 360
19	No manure	1,000	
20	Dung	1,400	− 420
21	No manure	960	
22	P_2O_5	1,700	+ 570
23	No manure	1,300	
24	P_2O_5 and dung ...	1,040	− 50
25	No manure	880	

Each plot $\frac{1}{20}$ acre. Ridges 3′ 6″. Sown 5th July, 1926. Harvested 25th November, 1926.

Increase (+) or decrease (−) of 4 plots of mucuna hay with N_2 added compared with no Manure.

+ 360 lb. per acre.
+ 720 „ „
+ 240 „ „
+ 420 „ „

Average + 435 ± 155 lb. per acre.

Increase (+) or decrease (−) of 4 plots of mucuna hay with P_2O_5 added compared with no Manure.

+ 820 lb. per acre.
+ 400 „ „
+ 40 „ „
+ 570 „ „

Average + 437 ± 155 lb. per acre.

Increase (+) or decrease (−) of 4 plots of mucuna hay with N_2 & P_2O_5 added compared with no Manure.

+ 620 lb. per acre.
+ 400 „ „
+ 360 „ „
− 50 „ „

Average + 332 ± 155 lb. per acre.

Root—mean—square—difference between pairs of neighbouring controls = 310·7.

Cost of cultivation in Man Days per acre = 52·2.

TABLE No. 4.

Groundnut Variety Test.

No. of Plot.	Variety.	Yields of dry decorticated lb. nuts per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
Block M.			
1	Kano standard	1,949	
2	Ilorin	1,608	− 284
3	Kano	1,836	
4	Zaria	2,054	+ 84
5	Kano	2,104	
6	American Y	2,020	− 143
7	Kano	2,222	
8	Chinese	2,212	+ 63
9	Kano	2,076	
10	Gambia	1,822	− 190
11	Kano	1,949	
12	Ilorin	1,728	− 446
13	Kano	2,400	
14	Zaria	2,048	− 170
15	Kano	2,036	
16	American Y	1,950	− 108
17	Kano	2,072	
18	Chinese	1,812	− 230
19	Kano	2,012	
20	Gambia	1,826	− 165
21	Kano	1,970	
22	Ilorin	1,642	− 11
23	Kano	1,337	
24	Zaria	1,336	+ 88
25	Kano	1,160	
26	American Y	1,308	− 55
27	Kano	1,567	
28	Chinese	1,223	− 462
29	Kano	1,804	
30	Gambia	1,598	− 261
31	Kano	1,915	
32	Ilorin	1,904	+ 13
33	Kano	1,866	
34	Zaria	1,788	− 66
35	Kano	1,842	
36	American Y	1,716	− 161
37	Kano	1,912	
38	Chinese	1,786	− 169
39	Kano	1,998	
40	Gambia	1,712	− 122
41	Kano	1,671	
42	Ilorin	1,259	− 471
43	Kano	1,790	
44	Zaria	1,868	+ 119
45	Kano	1,708	
46	American Y	1,804	− 32
47	Kano	1,964	
48	Chinese	1,658	Non-experimental.

Each plot ¼ acre. Ridges 3′ 6″. Sown 22nd June, 1926. Harvested, 19th November, 1926.

TABLE No. 4—*continued.*

Increase (+) or decrease (−) of 5 plots of Ilorin as compared with Kano.	Increase (+) or decrease (−) of 5 plots of Zaria as compared with Kano.	Increase (+) or decrease (−) of 5 plots of American Y as compared with Kano.
− 284 lb. per acre.	+ 84 lb. per acre.	− 143 lb. per acre.
− 446 „ „ „	− 170 „ „ „	− 108 „ „ „
− 11 „ „ „	+ 88 „ „ „	− 55 „ „ „
+ 13 „ „ „	− 66 „ „ „	− 161 „ „ „
− 471 „ „ „	+ 119 „ „ „	− 32 „ „ „
Average −239±109 lb. per acre.	Average +11±109 lb. per acre.	Average −99±109 lb. per acre

Increase (+) or decrease (−) of 4 plots of Chinese as compared with Kano.	Increase (+) or decrease (−) of 4 plots of Gambia as compared with Kano.
+ 63 lb. per acre.	− 190 lb. per acre.
− 230 „ „ „	− 165 „ „ „
− 462 „ „ „	− 261 „ „ „
− 169 „ „ „	− 122 „ „ „
Average − 199±121 lb. per acre.	Average − 184±121 lb. per acre.

Root—mean—square—difference between neighbouring control plots=243 lb. per acre.

Cost of cultivation in Man-days per acre = 79·7.

TABLE No. 5.

Date of Planting Maiwa and Mucuna.

No. of Plot.	Date of Planting.	Yields of Mucuna lbs. per acre.	Increase (+) or decrease (−) compared with mean of adjacent control.
Block D. 1–18			
1	10th July	752	
2	26th June	944	+ 236
3	10th July	664	
4	24th July	672	− 80
5	10th July	840	
6	26th June	928	− 112
7	10th July	1,240	
8	24th July	1,152	− 164
9	10th July	1,392	
10	26th June	1,640	+ 430
11	10th July	1,028	
12	24th July	1,380	+ 202
13	10th July	1,328	
14	26th June	1,688	+ 572
15	10th July	904	
16	24th July	744	− 340
17	10th July	1,264	
18	10th July	1,424	Non-experimental.

Each plot $\frac{1}{4}$ acre. Ridges 3′ 6″.

Increase (+) or decrease (−) of 4 plots planted 26th June compared with those planted 10th July.

+ 236 lb. per acre.
− 112 „ „ „
+ 430 „ „ „
+ 572 „ „ „

Average + 281 ± 154 lb. per acre.

Increase (+) or decrease (−) of 4 plots planted 24th July compared with those planted 10th July.

− 80 lb. per acre.
− 164 „ „ „
+ 202 „ „ „
− 340 „ „ „

Average − 90 ± 154 lb. per acre.

Root—mean—square—difference between pairs of neighbouring controls—307·8.

Cost of cultivation in man days per acre = 38.

TABLE No. 6.

Cost of Main Crops in Man Days per Acre.

Crop.	Preparation.	Planting.	Cultivation.	Harvest.	Store work.	Total M.D.P.A.
Cotton	8·65	3·95	14.33	13·9	8·28	49·11
Guinea Corn	·9	5·73	13·9	5·2	...	25·75
Groundnuts	8·8	5·15	11·21	54·0	9·17	88·33
Gero	·24	1·54	6·35	4·25	...	12·5
Legumes Interplanted	·82	1·98	3·42	1·38	...	7·6
„ Single Crop	...	5·37	14·18	3·38	...	22·93

TABLE No. 7.

Comparison of cost of Production and Revenue from Main Crops, 1926–27 Season.

Crop.	Cost in Man-days.	Average yield per acre in lb.	Cost of Crop in Man-days per lb.	Assumed market value per lb.	Calculated Return per acre (including transport to market).	Monetary Return per Man-day.	Nature of Crop.
					£ s. d.		
Cotton	49	250	0·19	2d.	2 1 0	10·03d.	Seed Cotton.
Guinea Corn	25·75	665	...	1·2d.	3 1 3	28·5d.	Threshed,
Gero	12·5	170	...	1·2d.	0 17 2	16·5d.	Threshed.
Groundnuts	88	1,000	0·08	1·2d.	4 12 8	14d.	Decorticated.

TABLE No. 8.

Monthly Rainfall and Mean Temperature.

Month.	Rainfall in inches.	Average fall over 6 years.	Mean temperature.	Mean temperature over 6 years.
January	...	...	69·1	69·5
February	...	...	74·3	75·4
March	...	0·14	81·6	83·1
April	0·01	0·41	87·7	88·9
May	1·29	1·42	89·1	88·4
June	6·96	3·98	84·2	84·2
July	7·53	7·23	79·7	79·5
August	9·70	12·39	81·3	77·9
September	2·03	5·56	83·2	80·3
October	0·05	0·78	80·9	80·5
November	...	...	77·4	77·5
December	..	...	72·2	72·0
Total	27·57	31·93	80·0	79·8